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F2P PL2 P37

(56) Documents Cited

GB 2283297 A  
GB 1507959 A

GB 2224803 A  
US 3860122 A

GB 2214259 A

(71) Applicant(s)

Stena Offshore Limited

(Incorporated in the United Kingdom)

Stena House, Westhill Industrial Estate, Westhill,  
ABERDEEN, AB32 6TQ, United Kingdom

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(72) Inventor(s)

Robert George Martin

Philip Vaughn Thomas

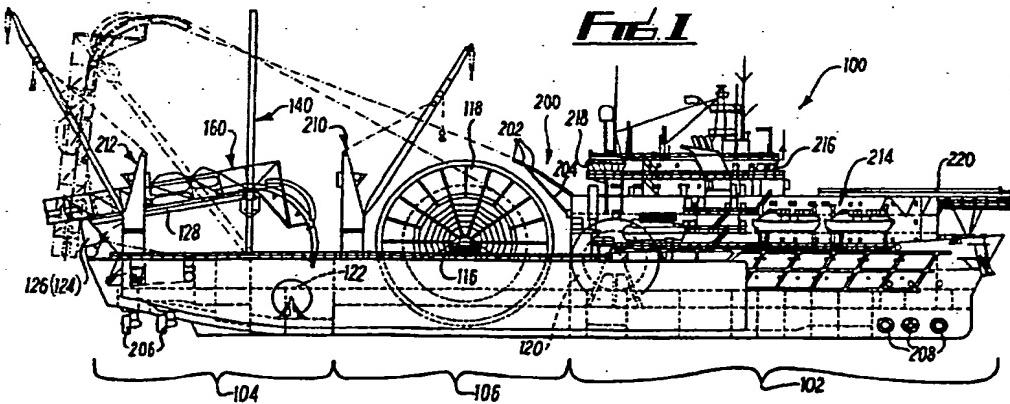
(74) Agent and/or Address for Service

Murgitroyd & Company

373 Scotland Street, GLASGOW, G5 8QA,  
United Kingdom

## (54) Pipelaying vessel

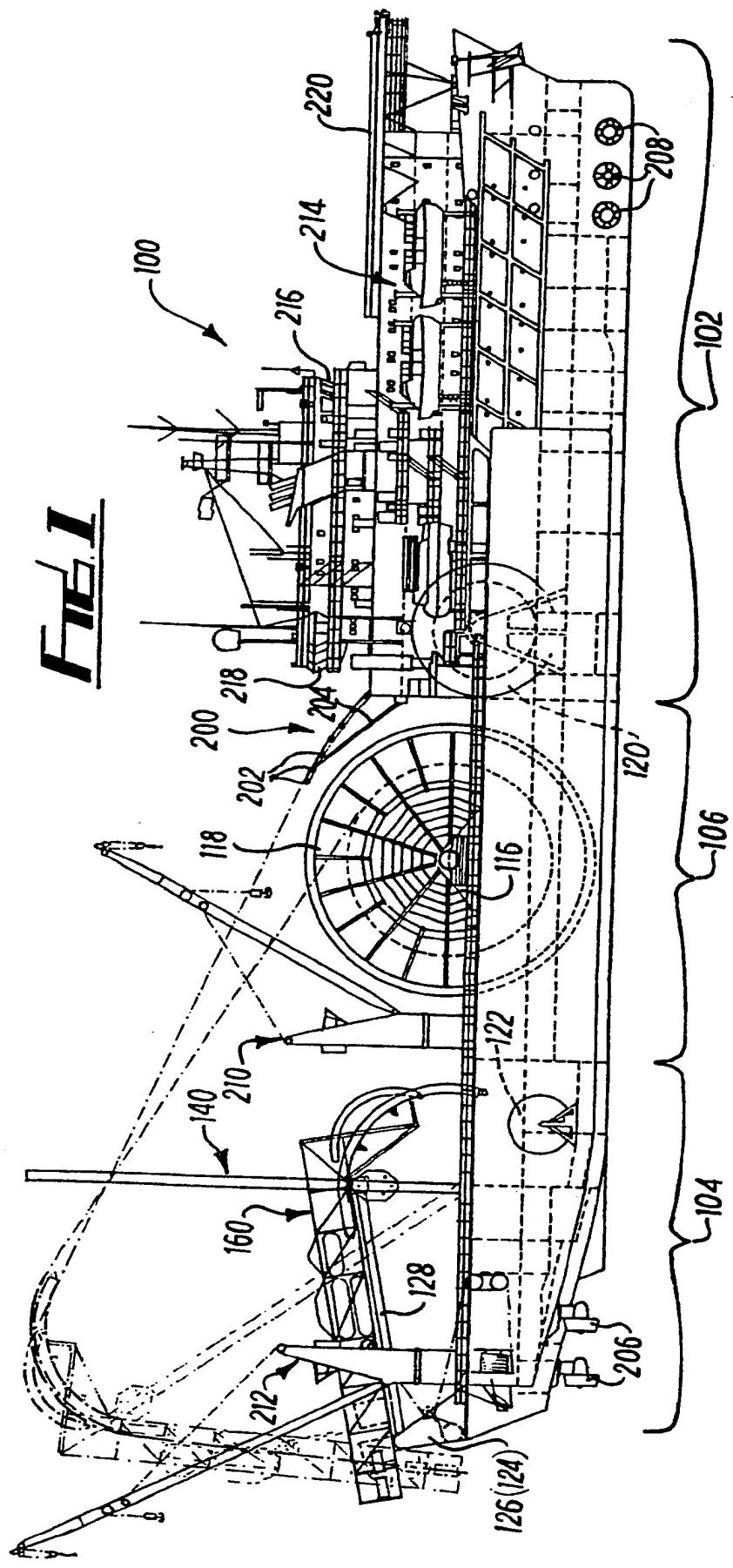
(57) A pipelaying vessel of the type in which pipe is laid from the vessel via a variable angle pipeline launching ramp (128) having pipeline straightening and tensioning means mounted thereon and having: an improved pipeline launching ramp arrangement including rack and pinion elevator means (140, 142, 144); an improved level winding mechanism for translating the pipeline straightening and tensioning means as the pipe is spooled onto or unspooled from the reel; sea fastening means for restraining axial movement of a pipe storage reel while the vessel is in transit, thereby increasing the maximum pipeline load for reel bearings (114, 116) (Fig 2) of a given load capacity; sponsons (108, 110) for providing additional flotation and strengthening the hull; an improved arrangement of auxiliary reels (120); a cantilever structure (200) for guiding auxiliary lines, providing access to the main reel and protecting the bridge 218 of the vessel; improved pipeline abandonment and recovery arrangements; an improved reel structure; and an improved pipeline clamping arrangement. A method of converting an existing vessel to a reel pipelaying vessel is also described.



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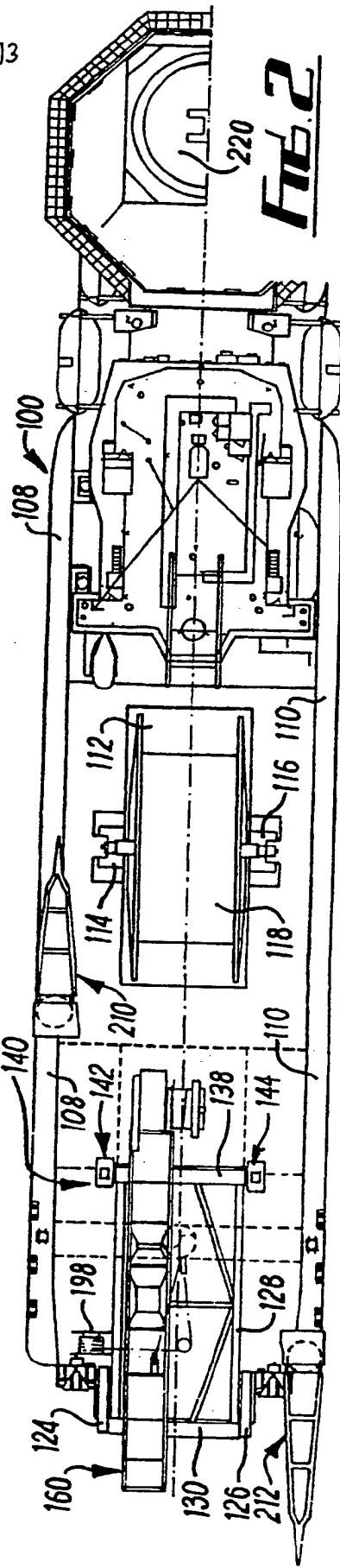
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FIG. 1



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FIG. 2



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FIG. 4

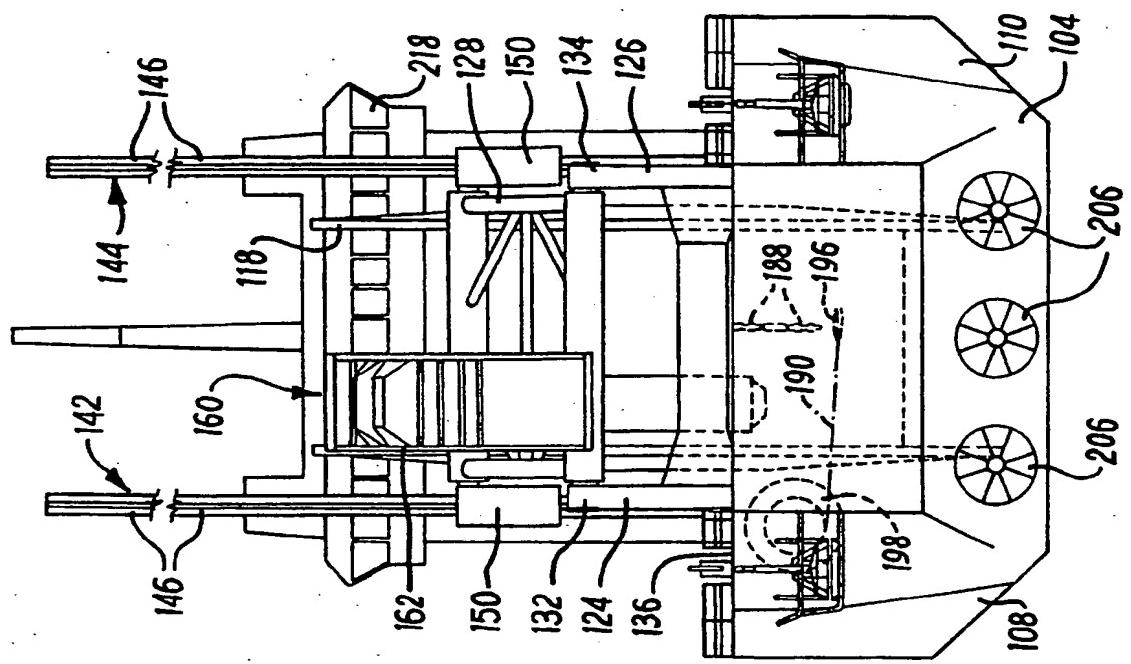


FIG. 3

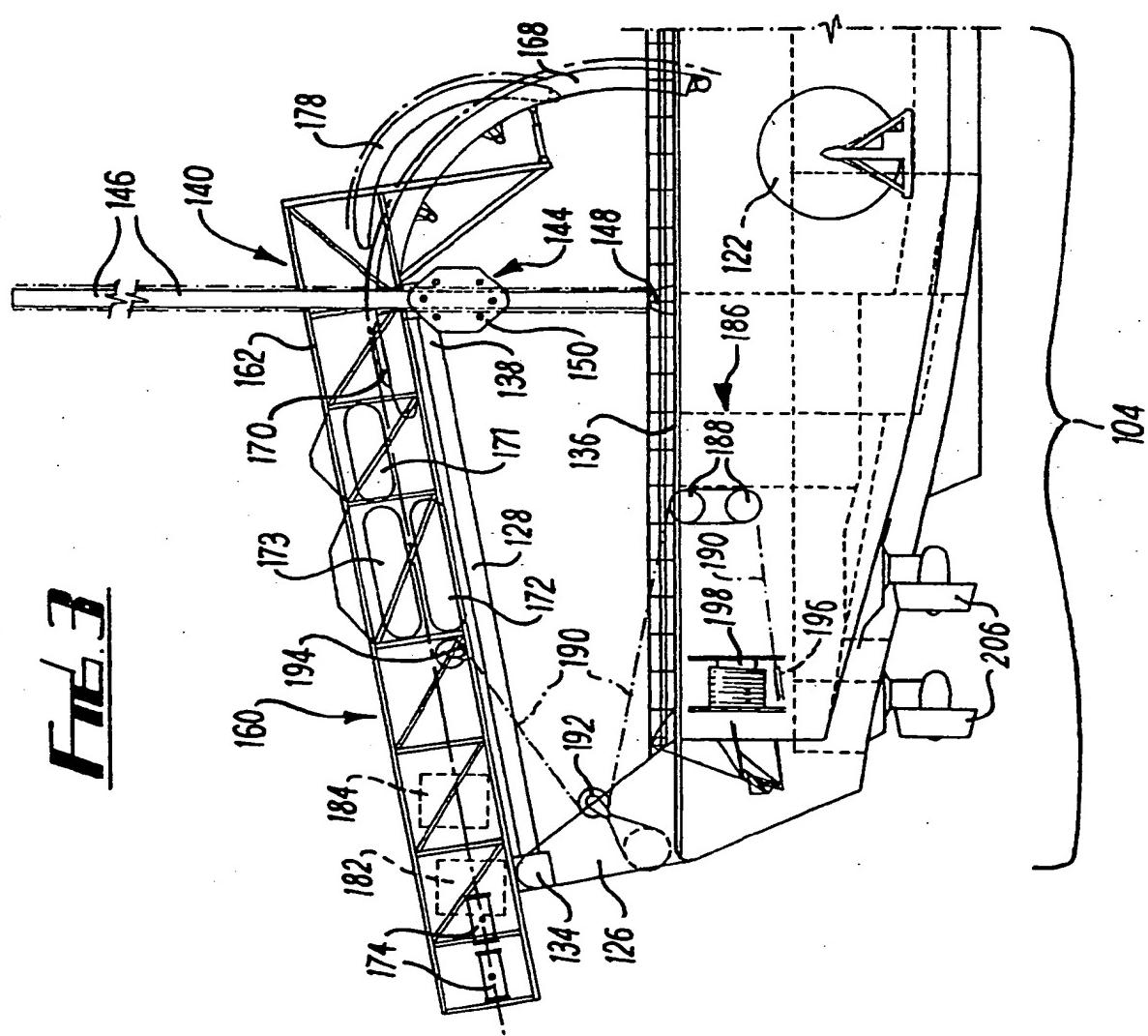


FIG. 6

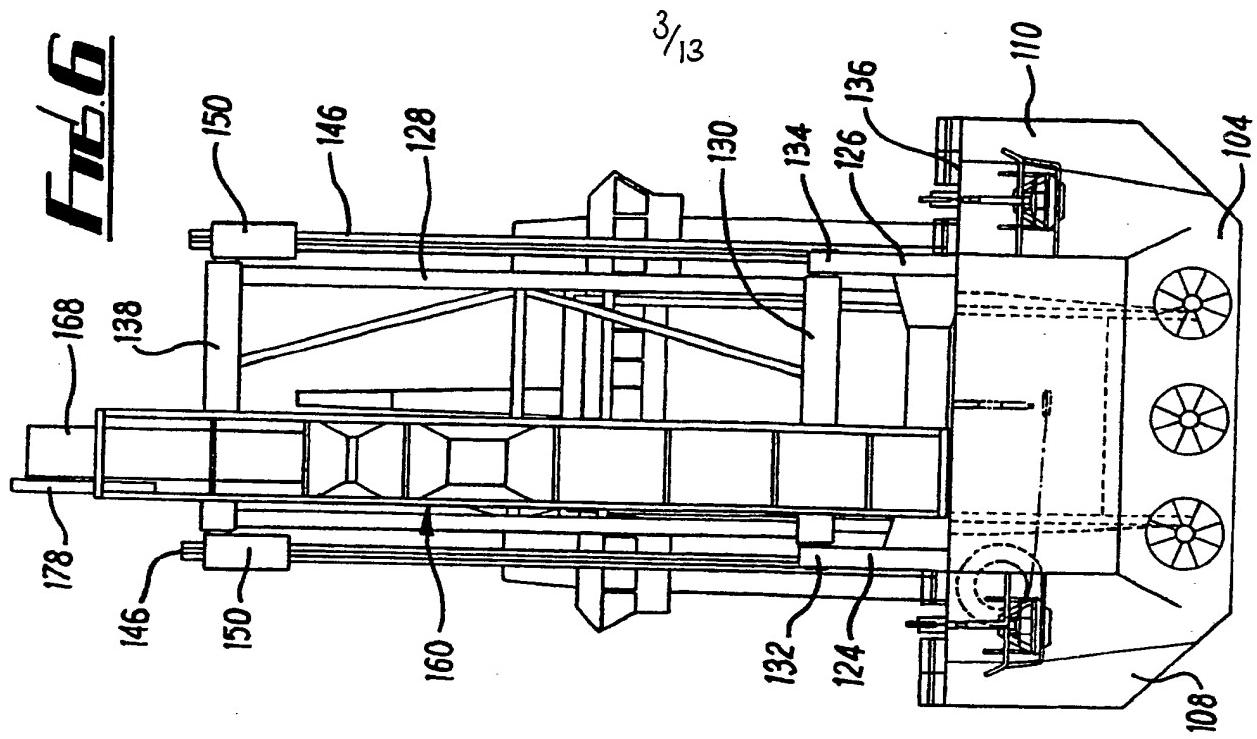
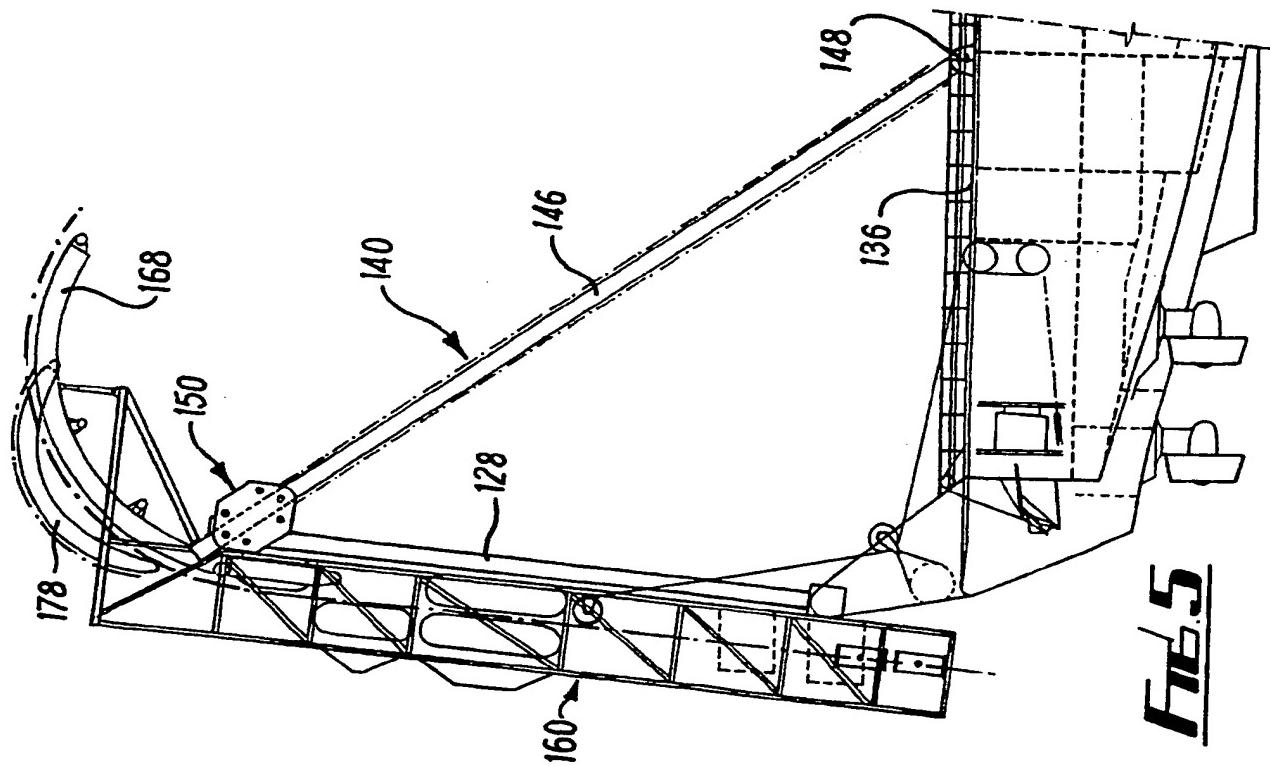
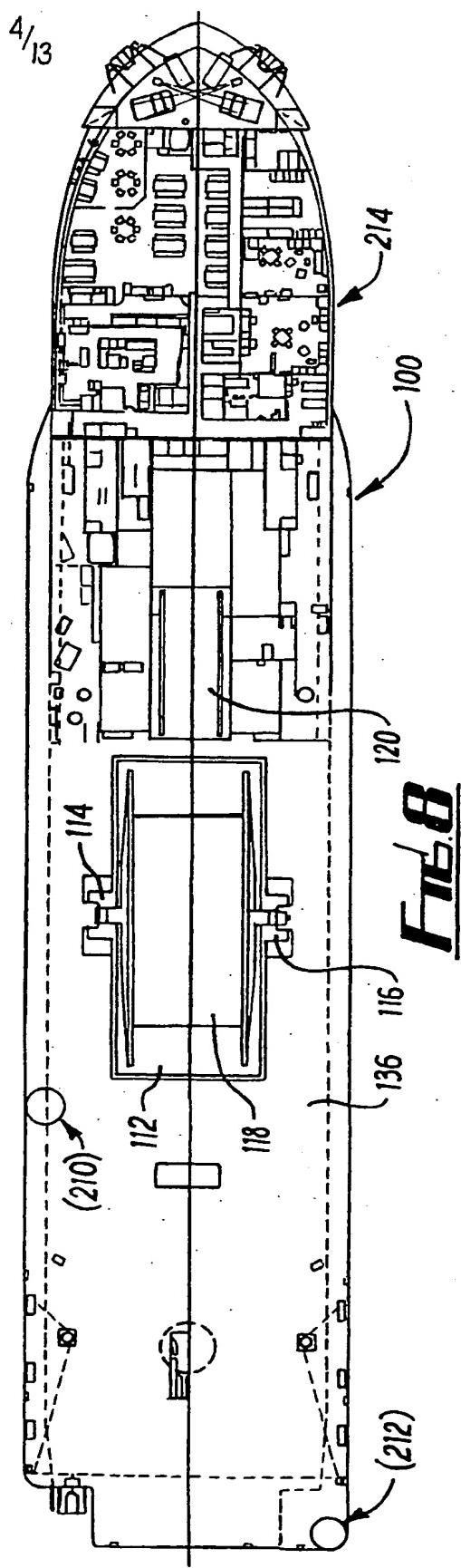
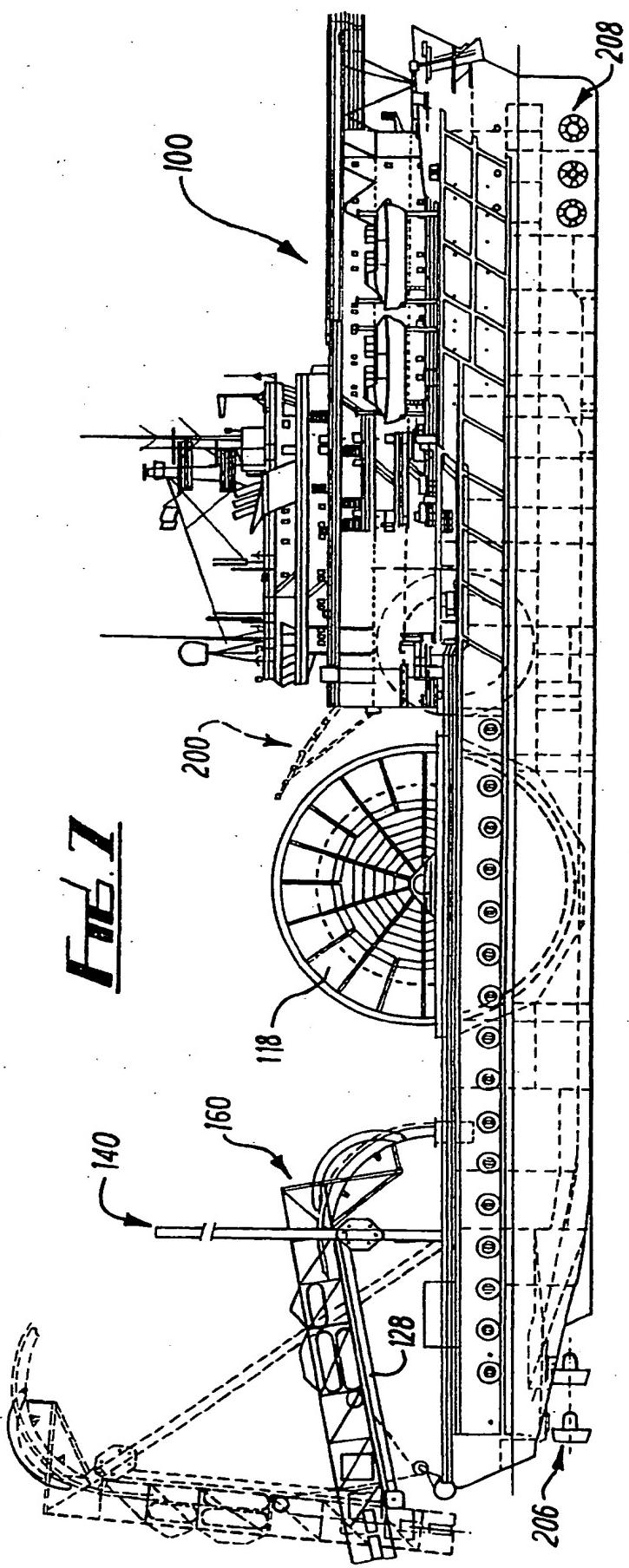
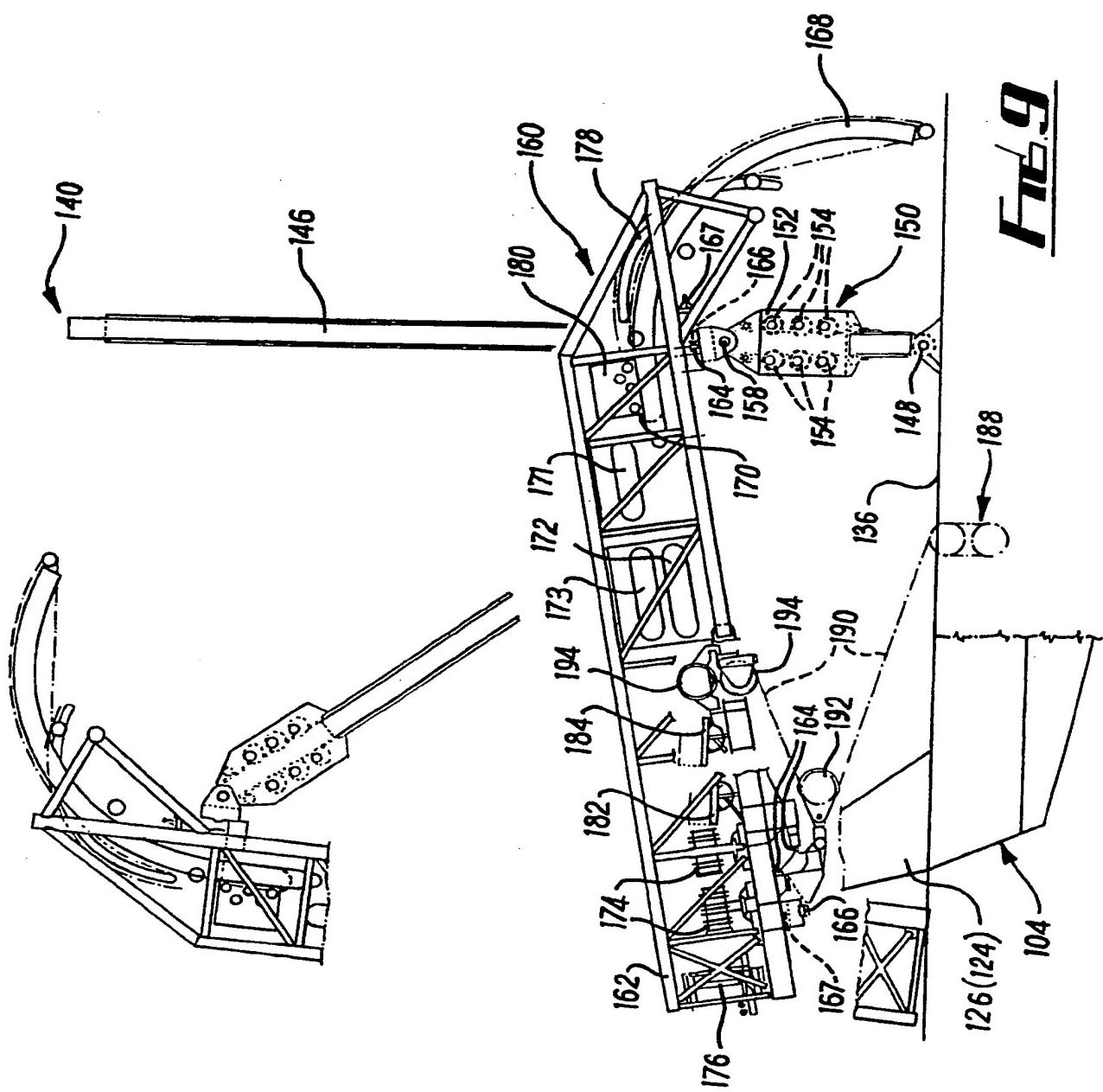


FIG. 5

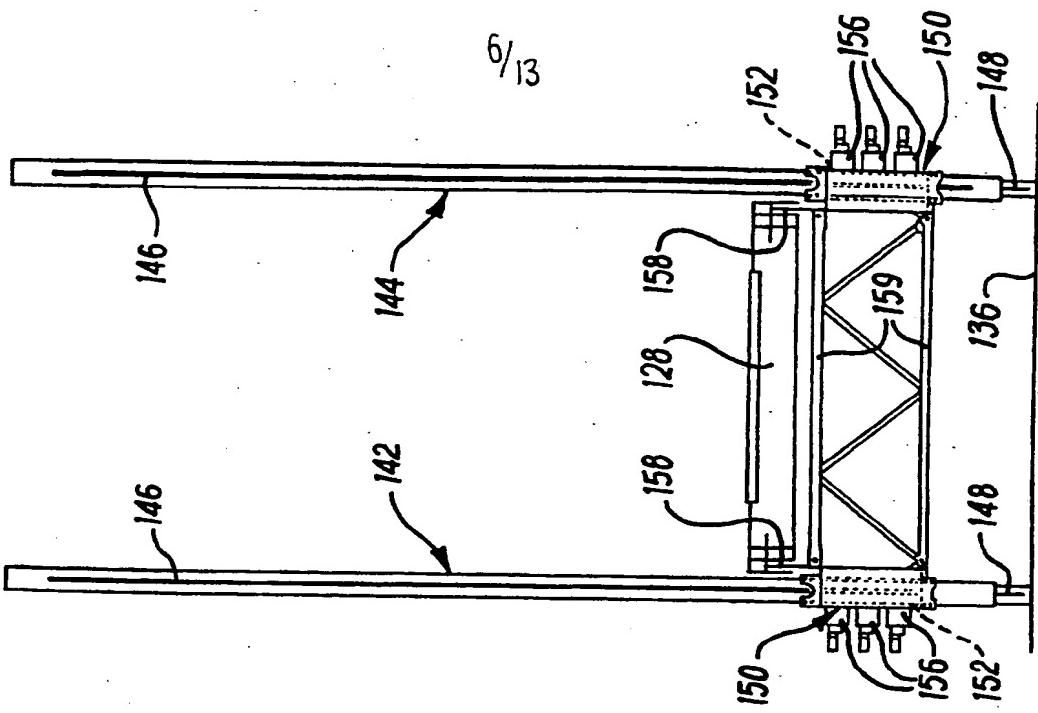




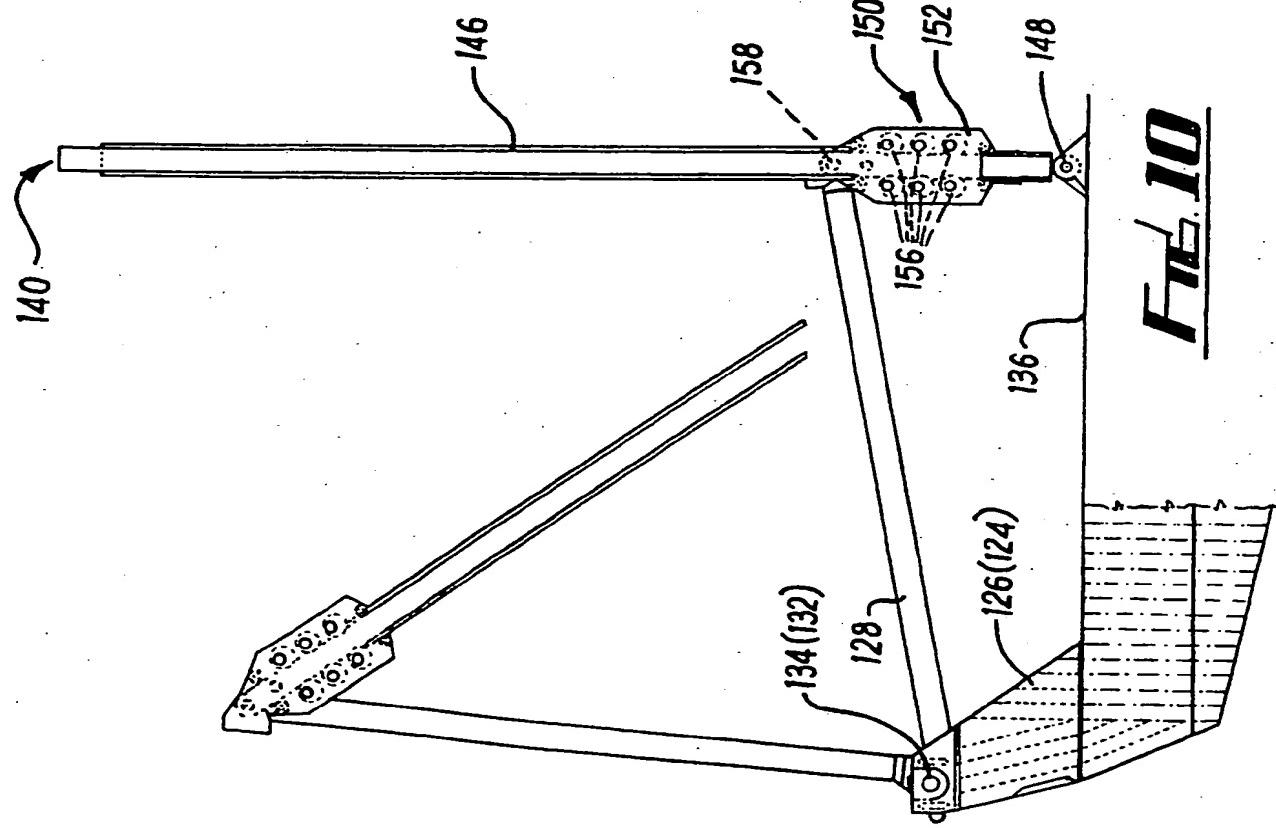
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**FIG. 9**



**Fig. 11**



**Fig. 10**

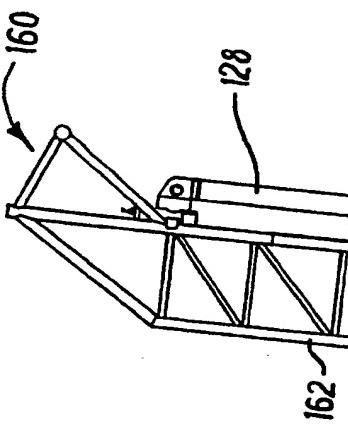


Fig. 15

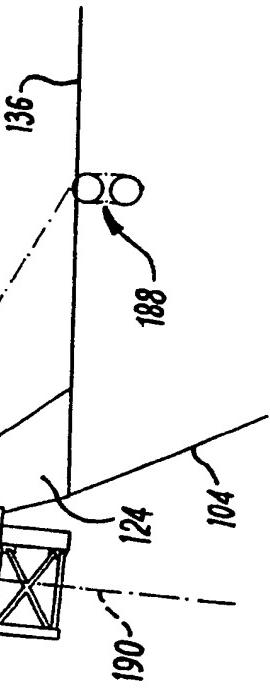


Fig. 14

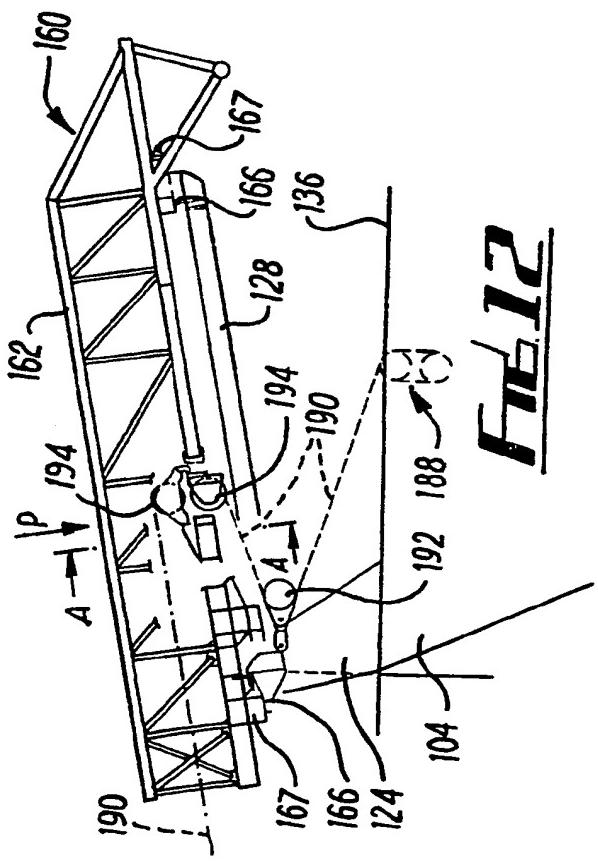


Fig. 12

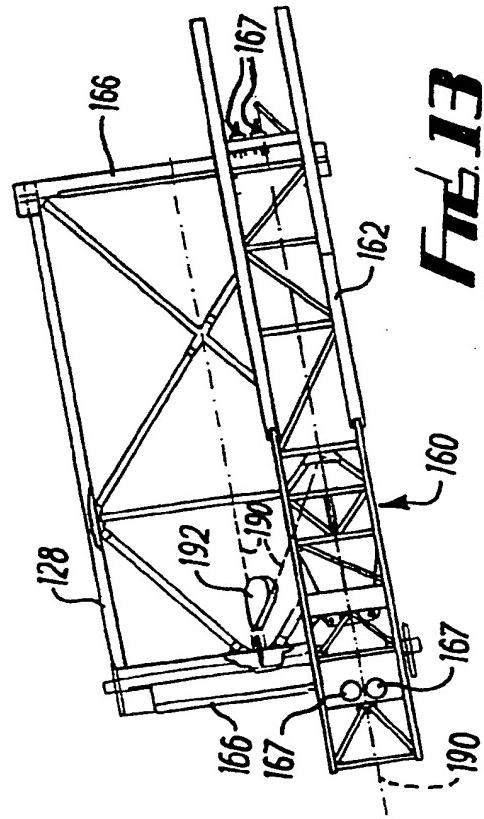


Fig. 13

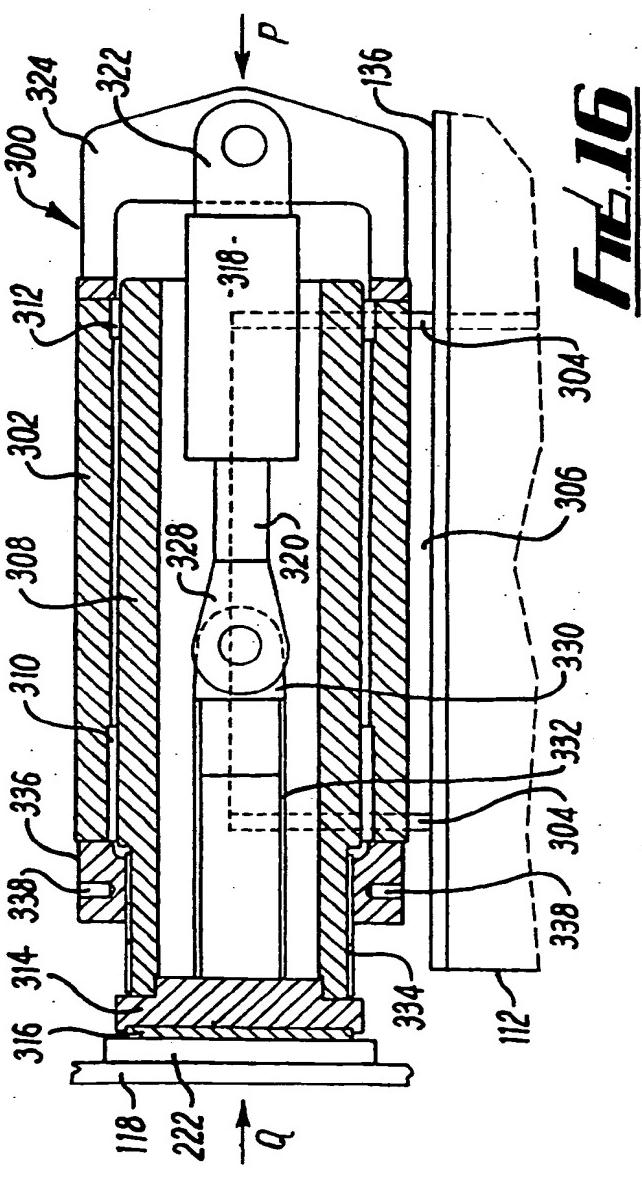
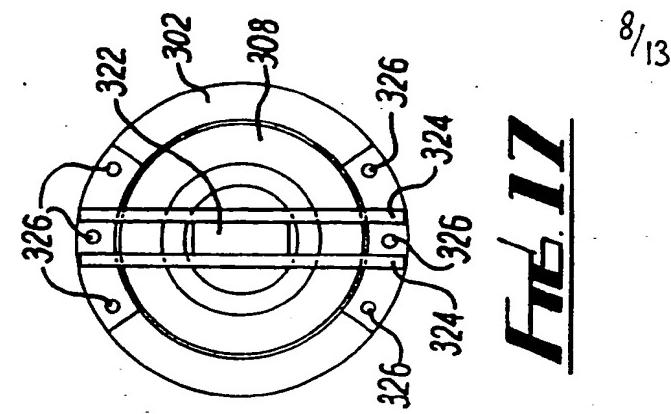


Fig. 16



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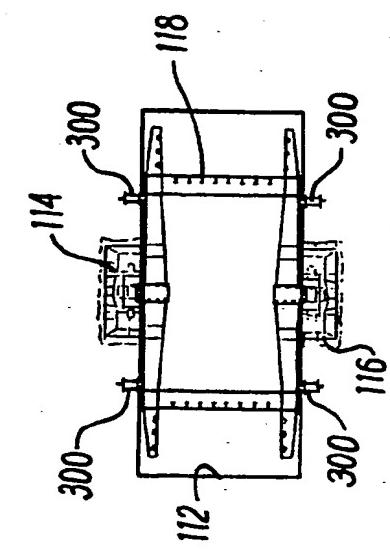
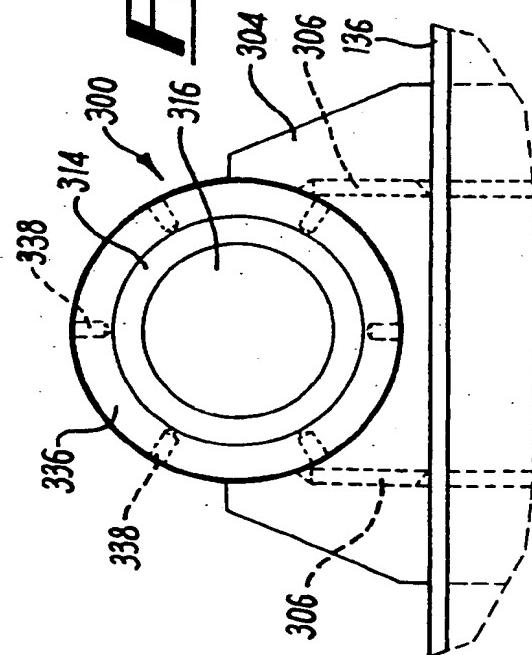


Fig. 19



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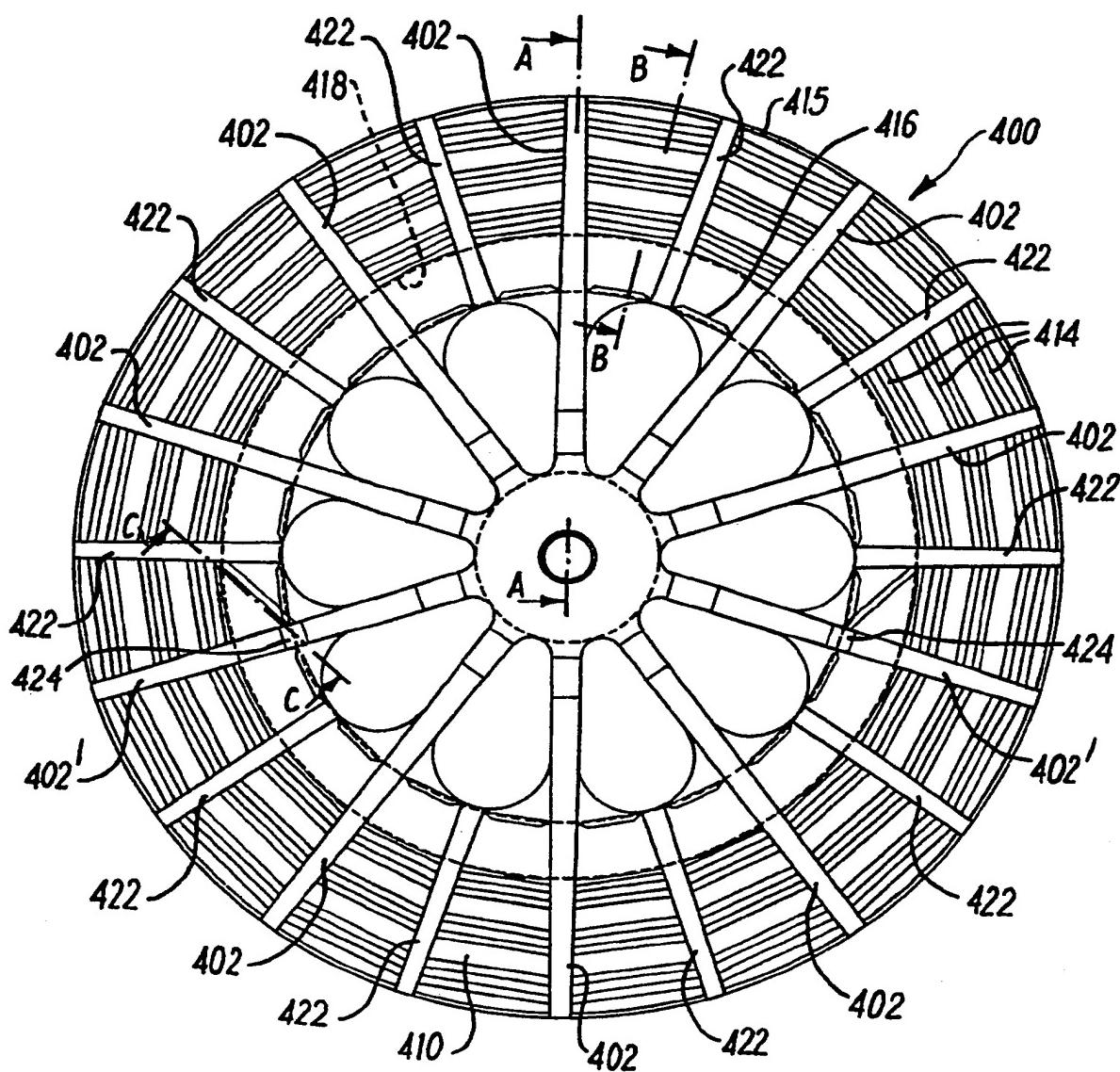


FIG. 20

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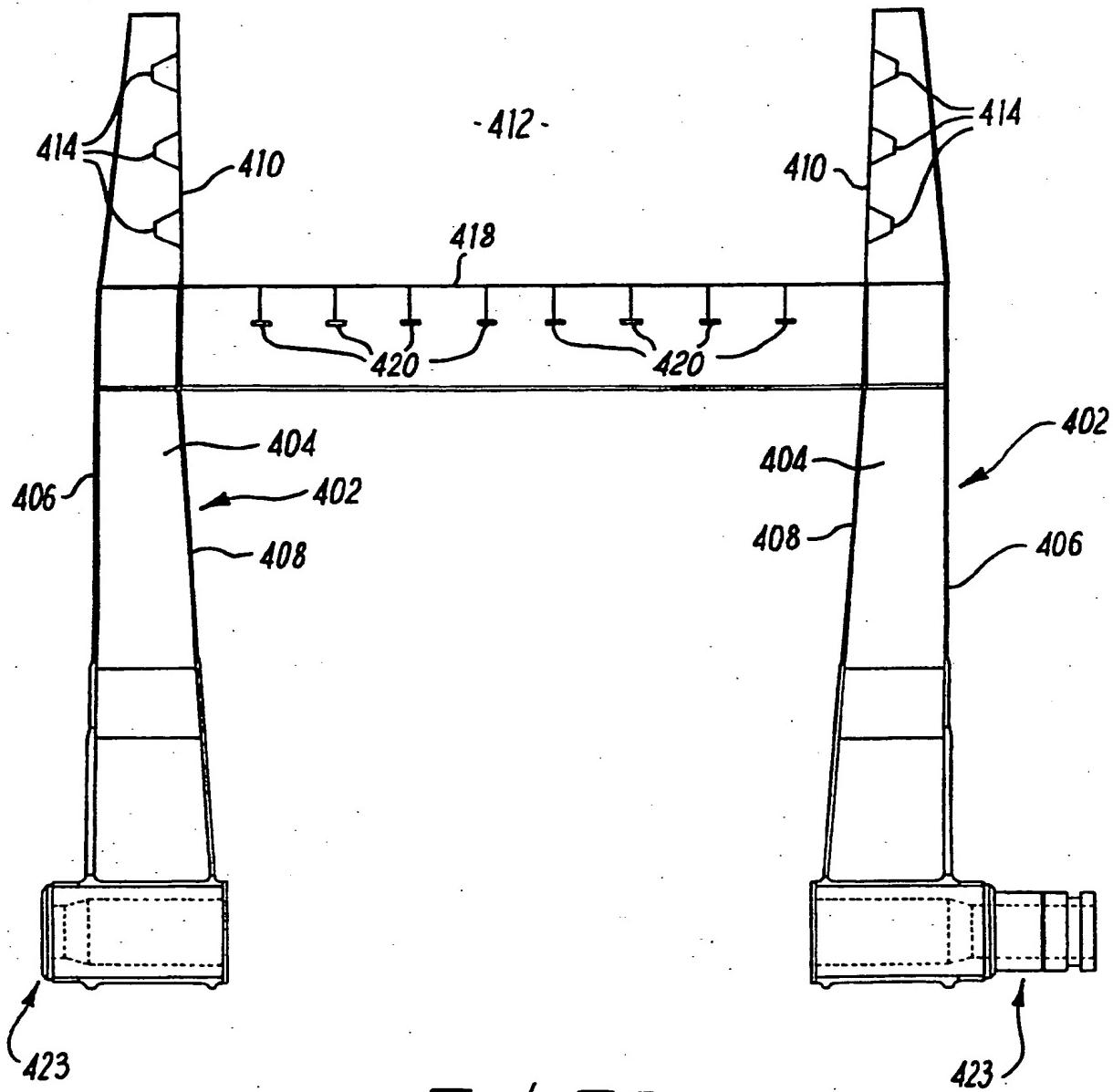
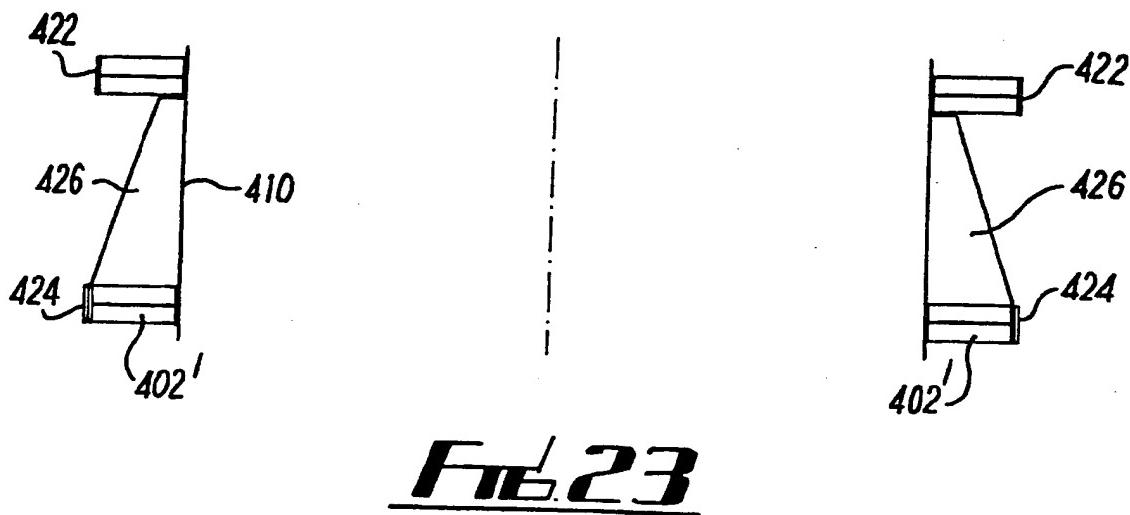
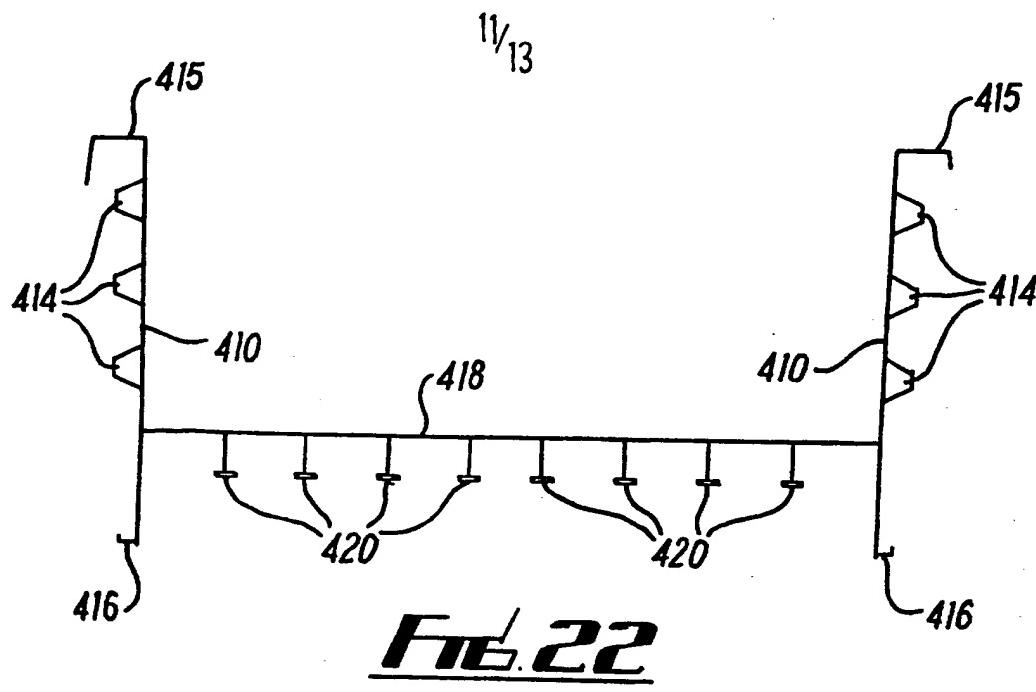


FIG. 21



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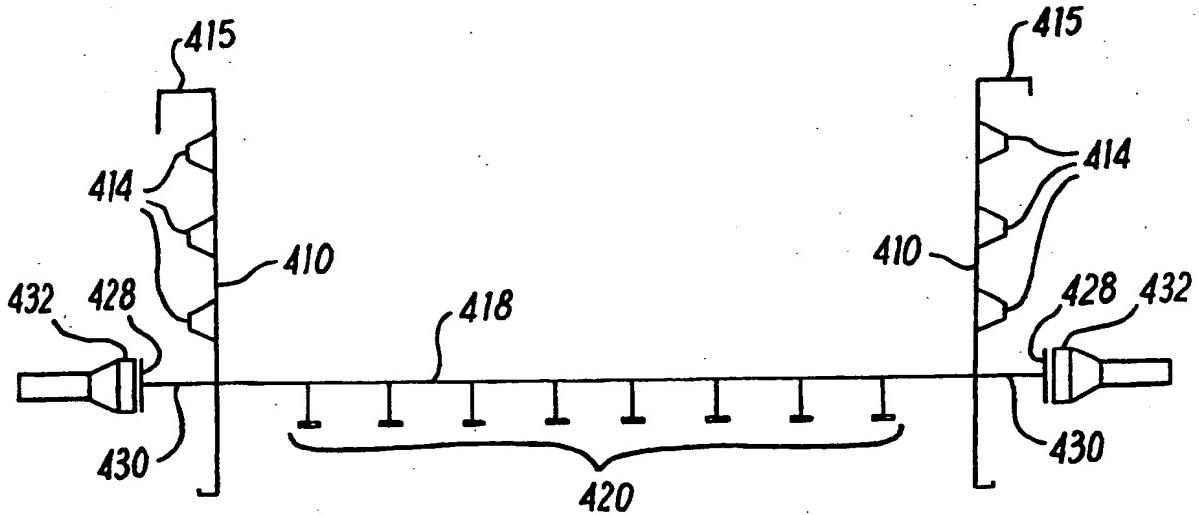


Fig. 24

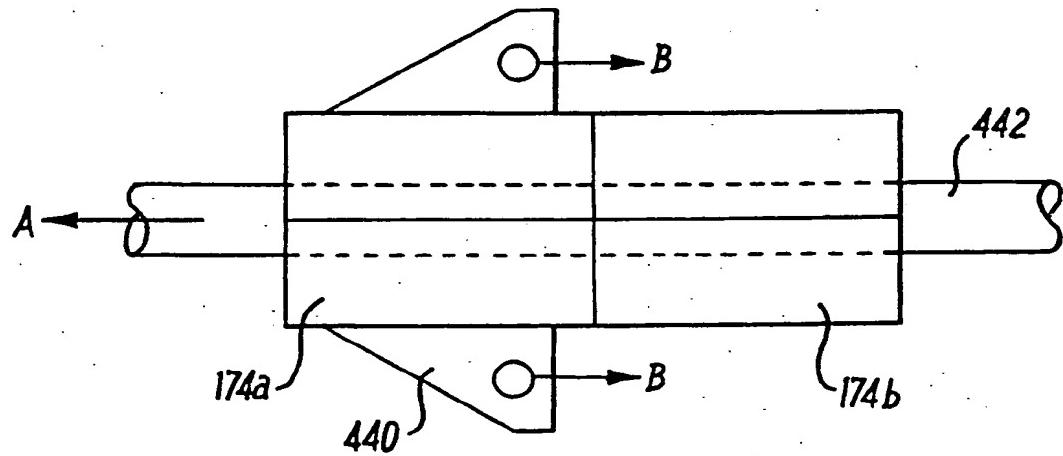
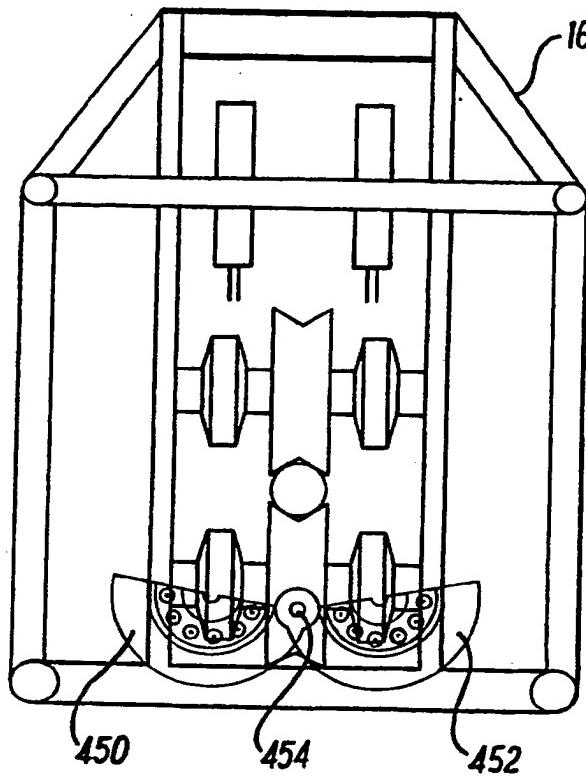
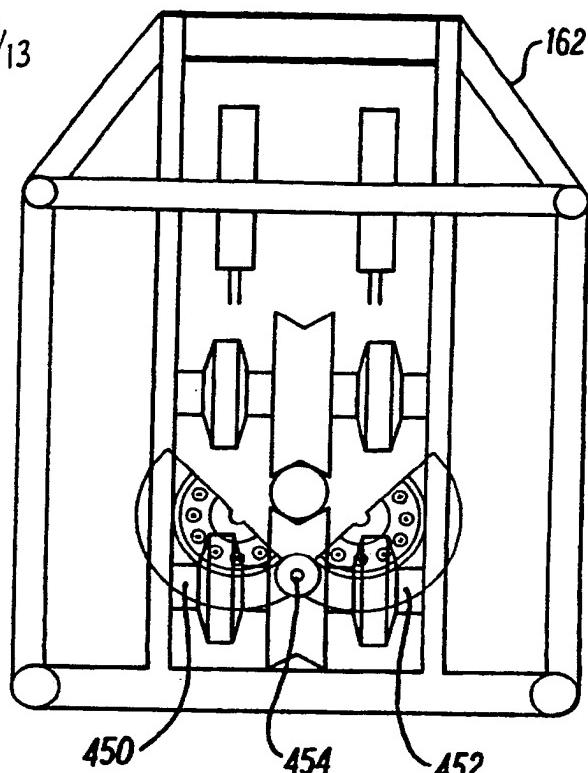


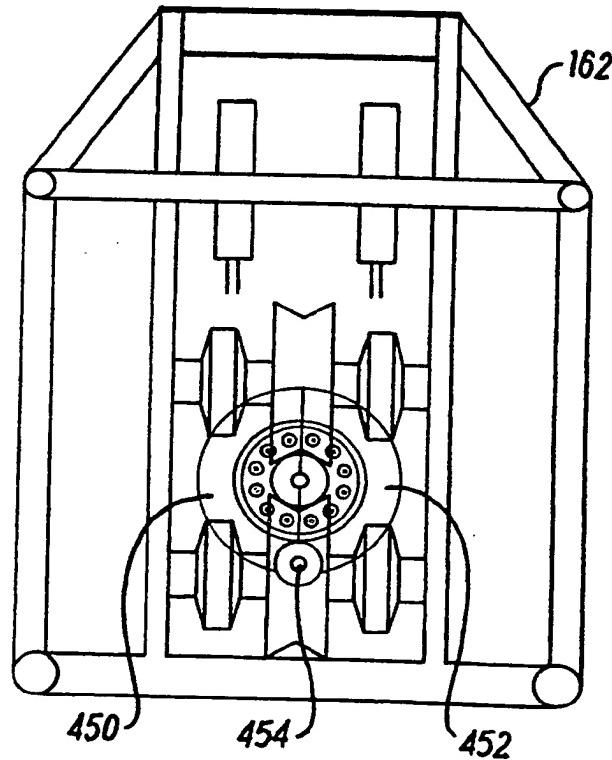
Fig. 26



*Fig. 25(a)*



*Fig. 25(b)*



*Fig. 25(c)*

1        "Pipelaying Vessel"

2

3        This invention relates to a pipelaying vessel, and more  
4        specifically but not exclusively relates to a self-  
5        propelled and dynamically-positioned reel pipelaying  
6        ship in which a pipe-spooling reel and associated pipe  
7        handling equipment are integrated into the structure of  
8        the ship. In some embodiments of the pipelaying ship,  
9        there is provision for the simultaneous laying of a  
10      plurality of pipes, or the simultaneous laying of one  
11      or more pipes together with one or more cables.

12

13      In prior-art pipelaying vessels as employed in laying  
14      offshore subsea pipelines for such uses as the  
15      gathering of oil and/or gas from offshore subsea wells,  
16      as, for example, in the Gulf of Mexico, it has been  
17      conventional to use one of two main methods to lay the  
18      pipe. In the first, or "stovepiping", method, a  
19      pipeline is fabricated on the deck of a lay barge by  
20      welding together individual lengths of pipe as the pipe  
21      is paid out from the barge. Each length of pipe is  
22      about 40 feet or 80 feet long. Thus, the pay-out  
23      operation must be interrupted periodically to permit  
24      new lengths of pipe to be welded to the string. The

1 stovepiping method requires that skilled welders and  
2 their relatively bulky equipment accompany the  
3 pipelaying barge crew during the entire laying  
4 operation; all welding must be carried out on site and  
5 often under adverse weather conditions. Further, the  
6 stovepiping method is relatively slow, with experienced  
7 crews being able to lay only one or two miles of pipe a  
8 day. This makes the entire operation subject to  
9 weather conditions which can cause substantial delays  
10 and make working conditions quite harsh. (A  
11 modification of the stovepiping technique known as the  
12 "J-lay" technique allows the laying of pre-assembled  
13 pipestrings up to 240 feet in length, but pipelaying is  
14 still discontinuous).

15

16 The other principal conventional method is the reel  
17 pipelaying technique. In this method, a pipeline is  
18 wound on the hub of a reel mounted on the deck of a lay  
19 barge. Pipe is generally spooled onto the reel at a  
20 shore base. There, short lengths of pipe can be welded  
21 under protected and controlled conditions to form a  
22 continuous pipeline which is spooled onto the reel.  
23 The lay barge is then towed to an offshore pipelaying  
24 location and the pipeline spooled off the reel between  
25 completion points. This method has a number of  
26 advantages over the stovepiping method, among them,  
27 speed (up to one mile per hour); lower operating costs  
28 (eg smaller welding crews and less welding equipment  
29 must be carried on the lay barge); and less weather  
30 dependency.

31

32 Historically, the technique of laying undersea  
33 fluid-carrying pipelines had its rudimentary beginnings  
34 in England in the 1940's in a War-time project known as  
35 "Operation Pluto". In the summer of 1944, 3-inch

1 nominal bore steel tubes, electrically flash-welded  
2 together, were coiled around floating drums. One end  
3 of the pipe was fixed to a terminal point; as the  
4 floating drums were towed across the English Channel,  
5 the pipe was pulled off the drum. In this manner,  
6 pipeline connections were made between the fuel supply  
7 depots in England and distribution points on the  
8 European continent to support the Allied invasion of  
9 Europe. (See Blair, J S, "Operation Pluto: The Hamel  
10 Steel Pipelines", Transactions of the Institute of  
11 Welding, February 1946).

12  
13 The broad concept of reel pipelaying was also disclosed  
14 in British Patent No. 601,103 wherein it was suggested  
15 that lengths of pipe can be joined together at the  
16 manufacturing plant and coiled onto a drum, mounted on  
17 a barge or ship; the loaded barge would then be moved  
18 to the desired marine location and the pipe unwound  
19 from the drum by fixing one end of the pipe and towing  
20 the barge away from the fixed location.

21  
22 While the concepts described in British Patent No.  
23 601,103 and those actually used in Operation Pluto were  
24 adequate for wartime purposes, no known further  
25 development work or commercial use of the technique of  
26 laying pipe offshore from reels was carried out after  
27 World War II. After a hiatus of about fifteen years,  
28 research into the reel pipelaying technique was renewed  
29 and was carried on by Gurtler, Herbert & Co, Inc of New  
30 Orleans, Louisiana (USA); by 1961, Gurtler, Herbert had  
31 sufficiently advanced the reel pipelaying technique to  
32 make it a commercially acceptable and viable method of  
33 laying pipe for the offshore petroleum industry, able  
34 to compete with the traditional stovepiping technique.  
35 The first known commercial pipelaying reel barge,

1       called the U-303, was built by Aquatic Contractors and  
2       Engineers, Inc, a subsidiary of Gurtler, Herbert, in  
3       1961. The U-303 utilised a large vertical-axis reel,  
4       permanently mounted on a barge and having horizontally  
5       orientated flanges (generally referred to in the trade  
6       as a "horizontal reel"). A combined straightener/level  
7       winder was employed for spooling pipe onto the reel and  
8       for straightening pipe as it was unspooled. The U-303  
9       first laid pipe commercially in September 1961, in the  
10      Gulf of Mexico off the coast of Louisiana and was used  
11      successfully during the 1960's to lay several million  
12      linear feet of pipe of up to 6 inches diameter. The  
13      U-303 reel pipelaying barge is described in US Patent  
14      No. 3,237,438 (Tesson) and US Patent No. 3,372,461  
15      (Tesson).

16

17      The successor to the U-303, currently in use in the  
18      Gulf of Mexico and known in the trade as the  
19      "Chickasaw", also utilises a large horizontal reel,  
20      permanently mounted on the barge such that it is not  
21      readily movable from one carrier vessel to another.  
22      Various aspects of "Chickasaw" are described in the  
23      following US Patents:

24

25           Sugasti, et al -     US Patent No. 3,630,461  
26           Gibson            -     US Patent No. 3,641,778  
27           Mott et al       -     US Patent No. 3,680,432  
28           Key et al       -     US Patent No. 3,712,100  
29

30      Commercial reel pipelaying techniques require the use  
31      of certain pipe handling equipment in addition to the  
32      reel. Among such pipe handling equipment essential to  
33      any commercial reel pipelaying system is a straightener  
34      mechanism. This may take the form of a series of  
35      rollers or tracks, or any other arrangement which

1 imparts sufficient reverse bending force to the pipe to  
2 remove residual curvature such that after unspooling,  
3 the pipe will lay substantially straight on the sea  
4 bottom. No such pipe-conditioning apparatus was used  
5 in "Operation Pluto" or contemplated in the British  
6 Patent No. 601,103.

7

8 US Patents 3,982,402 and RE30486 (Lang et al) describe  
9 an apparatus for laying pipe from a vertical reel in  
10 which the pipe conditioning apparatus is pivotable to  
11 adjust the lift-off angle of the pipe relative to the  
12 horizontal (eg the deck of a ship) as a function of the  
13 water depth in which the pipe is being laid. This has  
14 distinct commercial advantages, especially where the  
15 reel pipelaying system is incorporated into a  
16 self-propelled ship capable of travelling to different  
17 job sites, having different pipe size and/or lay depth  
18 requirements.

19

20 An early concept for a reel pipelaying ship is  
21 described in Goren, et al, "The Reel Pipelay Ship - A  
22 New Concept", Offshore Technology Conference  
23 Proceedings, May 1975 (Paper No OTC 2400). This paper  
24 (hereinafter the Goren, et al 1975 OTC Paper) described  
25 advantages and operating features of a proposed reel  
26 pipelaying ship. However, the cost of construction of  
27 a ship as described there was estimated to be of the  
28 order of \$100,000,000.

29

30 The research and development work for the ship  
31 described in the Goren, et al paper was subsequently  
32 materially revised in numerous major respects, and  
33 substantial changes and improvements were made to  
34 achieve the design of a substantially different reel  
35 pipelaying ship which is described in the following US

1      Patents:-  
2  
3

4            Springett, et al        -        US Patent No. 4,230,421  
5            Uyeda, et al            -        US Patent No. 4,269,540  
6            Yenzer, et al          -        US Patent No. 4,297,054  
7            Springett, et al        -        US Patent No. 4,340,322  
8            Uyeda, et al            -        US Patent No. 4,345,855  
9

10          The vessel described in these Patents was constructed  
11          and is currently in use in various offshore oil fields,  
12          being known in the offshore oil industry as the  
13          "Apache" (now re-named the "Stena Apache"). This  
14          vessel is a self-propelled dynamically-positioned reel  
15          pipelaying ship which has a specially constructed hull  
16          comprising a reel support structure for rotatably  
17          mounting a vertical reel for unspooling a rigid-walled  
18          pipeline. Only a single pipeline was originally  
19          handled by this ship, though the "Apache" was  
20          subsequently modified by the addition of an auxiliary  
21          reel positioned forward of the main reel to enable the  
22          laying of "piggyback" lines strapped to the main  
23          pipeline. Other pipe handling equipment includes a  
24          pipe bending radius controller; pipe straightening  
25          equipment; clamping assemblies; a stern pipe guide  
26          assembly and a level wind assembly. A tensioning  
27          assembly is also arranged on a support ramp assembly.  
28          The pipe exit angle or the water entry angle is from  
29          18° to about 60° since this is the range of angular  
30          movement of the support ramp assembly. The upper part  
31          of this range of the pipe water entry angles is  
32          sufficient to accommodate laying a single pipeline in  
33          approximately 3,000 feet water depth. In order to lay  
34          pipe at greater depths it is necessary to increase the  
35          pipe water entry angle.

1 The "Stena Apache" vessel is not equipped to lay  
2 multiple lines since it has but a single main reel and  
3 does not have adequate unused deck space to permit the  
4 convenient placement of auxiliary reels. An early  
5 suggestion which was made during the vessel's  
6 construction phase and mentioned in the above Patents,  
7 was that portable reels could be placed on the "Apache"  
8 deck to permit stern bundling of smaller lines with the  
9 pipeline from the main reel. These smaller lines were  
10 not required to be passed through the pipe handling  
11 equipment with the main reel pipeline according to the  
12 suggestion and there were no operative disclosures as  
13 to forming a juxtaposed plurality of operational lines  
14 by contact with a laying device which is adapted to  
15 move all the lines at a common velocity. This stern  
16 bundling suggestion was made in the OTC Paper No. 3069,  
17 May 8-11, 1978.

18

19 There are increasing requirements in the offshore  
20 petroleum industry for laying single or multiple  
21 operational lines in deep water at depths greater than  
22 3,000 feet and in remote areas far from supply bases.  
23 To be commercially viable a pipelaying vessel should  
24 preferably also be capable of laying either single or  
25 multiple operational lines in shallow waters of less  
26 than 2,000 feet up to 3,000 feet depth. The reel  
27 pipelaying vessel of this invention (as defined below)  
28 represents a new and different concept for meeting  
29 these needs.

30

31 It is also desirable that the stern deck space around  
32 the pipelaying equipment be more easily and safely  
33 accessible.

34

35 While it is technically feasible to design and build a

1 ship specifically to provide several or all of the  
2 abovementioned desirable features, such a ship would be  
3 relatively expensive. On the other hand, there are  
4 many sea-going vessels that are currently surplus to  
5 requirements and hence available at relatively low cost  
6 such that the cost of conversion to reel-lay capacity  
7 is potentially more economical than new-build.  
8 However, selection of a vessel to be modified, and the  
9 actual modification procedures, require to be  
10 individually and collectively controlled in non-obvious  
11 ways to avoid excessive costs and unsatisfactory  
12 results.

13

14 Certain aspects of the present invention will also be  
15 shown to be applicable to new-build vessels, and/or to  
16 retrofitting/upgrading an existing pipelaying vessel.  
17

18 According to one aspect of the present invention there  
19 is provided a pipe-launching ramp, said ramp comprising  
20 a planar frame having bearing means at or towards one  
21 end thereof for rotatably mounting the ramp on ramp-  
22 mounting bearings of a pipelaying vessel, and coupling  
23 means located at or towards the other end of the frame  
24 for coupling of the ramp to a ramp elevation control  
25 means for controllably varying the elevation of the  
26 ramp.  
27

28 Preferably, said ramp elevation control means comprises  
29 variable-length ramp support means adapted to be  
30 anchored at or adjacent one end thereof upon fixed  
31 structure of the vessel and at or adjacent the other  
32 end of a variable length portion of the support to the  
33 ramp at a location thereon not adjacent said rotational  
34 mounting of said ramp.  
35

1 Preferably also, said variable-length ramp support  
2 means comprises a pair of rack and pinion elevators  
3 located one on each side of said ramp and conjointly  
4 operable to vary the elevation of said ramp with  
5 respect to said vessel.

6  
7 Preferably also, said pipe-launching ramp comprises a  
8 pipe radius control means for imparting a substantially  
9 uniform radius of curvature to a length of pipe de-  
10 spooled from said reel in pipelaying operation of said  
11 vessel.

12  
13 Preferably also, said pipe launching ramp further  
14 includes pipe gripping means for gripping a pipe being  
15 de-spooled over said ramp to apply straightening and/or  
16 tensioning forces to said pipe.

17  
18 Preferably also, said pipe-launching ramp comprises  
19 level-wind means for accommodating variations in the  
20 lateral positioning of a length of pipe spooled onto  
21 said reel as a plurality of side-by-side turns, during  
22 spooling and de-spooling of said length of pipe.

23  
24 Preferably also, said ramp includes at least two  
25 levelwind-mounting crossbeams; said levelwind means  
26 comprising a rectangular lattice mounted for lateral  
27 movement on said crossbeams, lateral movement control  
28 means for laterally moving said lattice on said  
29 crossbeams, radius control means carried on said  
30 lattice for imparting a uniform curvature to a pipe  
31 being de-spooled over said ramp, and pipe gripping  
32 means carried by said lattice for gripping a pipe being  
33 de-spooled over said ramp to apply straightening and/or  
34 tensioning forces to said pipe.

35

1 As compared to the pipe-launching ramps described in  
2 WO93/06401 and WO93/06402 wherein a flexible levelwind  
3 is mounted on five transverse rails on a wide stiff  
4 truss, in the present invention the levelwind is  
5 constructed as a stiff rectangular lattice running on  
6 two crossbeams carried by a ramp which is simply a  
7 planar frame, this arrangement being lighter than the  
8 abovementioned prior art for a given load capacity.  
9

10 The levelwind lattice can be boxed in or surrounded to  
11 provide full weather protection, and is preferably  
12 equipped with a dual bulkhead/platform system to  
13 provide a working location which allows personnel to  
14 work on the lattice whether the ramp is near horizontal  
15 or near vertical. Access to the working location can  
16 be by a ladder system on one side of the levelwind  
17 and/or by a man-carrying lift on the other side of the  
18 levelwind.

19

20 The radius control means and the pipe gripping means  
21 can be as described in the abovementioned PCT  
22 publications, but a preferred ramp elevator in  
23 accordance with part of the present invention, for  
24 controllably varying the inclination of the ramp, is  
25 very different in that the preferred ramp elevator has  
26 its lower end(s) at a fixed location(s) on the vessel  
27 rather than travelling along deck rails in the above  
28 PCT publications; this arrangement of the present  
29 invention concentrates ramp-elevating loads at discrete  
30 points, thereby minimizing the required extent of  
31 under-deck stiffening and hence cost.  
32

33 In accordance with a second aspect of the invention  
34 there is provided a pipelaying vessel including a pipe-  
35 launching ramp according to the first aspect of the

1 invention.

2  
3 Embodiments of the invention will now be described by  
4 way of example, with reference to the accompanying  
5 drawings wherein:-

6  
7 Fig. 1 is a starboard elevation of a reel pipelaying  
8 vessel in accordance with the present invention;

9  
10 Fig. 2 is a plan view of the vessel of Fig. 1;

11  
12 Fig. 3 is a starboard elevation (to an enlarged scale)  
13 of the stern area of the vessel of Fig. 1 with a  
14 pipe-launching stern ramp to its lowest elevation;

15  
16 Fig. 4 is a stern view corresponding to Fig. 3;

17  
18 Fig. 5 is a view corresponding to Fig. 3 but with the  
19 ramp at its highest elevation;

20  
21 Fig. 6 is a stern view corresponding to Fig. 5;

22  
23 Fig. 7 is a starboard elevation of another form of reel  
24 pipelaying vessel in accordance with the present  
25 invention;

26  
27 Fig. 8 is a plan view of the main deck of the vessel of  
28 Fig. 7, ie, with the vessel bridge and upper decks  
29 removed;

30  
31 Fig. 9 is a starboard elevation of a modified version  
32 of the pipe-launching ramp and associated equipment  
33 forming part of the vessel of Fig. 7;

34  
35 Fig. 10 is a starboard elevation of ramp-mounting

1      bearings and a ramp elevation controller associated  
2      with the ramp of Fig. 9;

3

4      Fig. 11 is a front elevation of the arrangement of  
5      Fig. 10;

6

7      Fig. 12 is a view from the starboard side of the  
8      reeving arrangement of an abandonment and recovery  
9      system (A&R system) associated with the ramp of Fig. 9,  
10     shown with the ramp at its minimum elevation;

11

12     Fig. 13 is a view from above of the arrangement of  
13     Fig. 12, as seen from the direction of the arrow "P" in  
14     Fig. 12;

15

16     Fig. 14 is a cross-section of part of the arrangement  
17     of Fig. 12, taken on the line A-A in Fig. 12;

18

19     Fig. 15 is a view corresponding to Fig. 12 but with the  
20     ramp at its highest elevation;

21

22     Fig. 16 is a longitudinal section of a reel-clamping  
23     chock for use with the present invention;

24

25     Fig. 17 is an outside end view of the arrangement of  
26     Fig. 16, as viewed in the direction of the arrow "P" in  
27     Fig. 16;

28

29     Fig. 18 is an inside end view of the arrangement of  
30     Fig. 16, as viewed in the direction of the arrow "Q" in  
31     Fig. 16;

32

33     Fig. 19 is a plan view, to a much-reduced scale, of a  
34     reel-clamping chock array applied to a reel;

35

1 Fig. 20 is a side view of a preferred embodiment of a  
2 main reel for use with the vessel of Figs. 1 to 19;  
3  
4 Fig. 21 is a sectional view on line A-A of Fig. 20;  
5  
6 Fig. 22 is a sectional view on line B-B of Fig. 20;  
7  
8 Fig. 23 is a sectional view on line C-C of Fig. 20;  
9  
10 Fig. 24 is a view similar to Fig. 23, showing a  
11 modified chocking arrangement;  
12  
13 Figs. 25 (a),(b) and (c) are schematic illustrations of  
14 a preferred arrangement of a main pipeline clamp; and  
15  
16 Fig. 26 is a schematic illustration of a particularly  
17 preferred arrangement of pipeline clamps.  
18  
19 Referring first to Figs. 1 and 2, these show  
20 respectively starboard and plan views of a reel  
21 pipelaying vessel 100 which is similar in certain  
22 respects to known forms of reel pipelaying vessels, for  
23 example as disclosed in WO93/06401 and WO93/06402.  
24 However, general and particular aspects of the vessel  
25 100 are distinctively different from the prior art, as  
26 will be detailed below.  
27  
28 The vessel 100, to be known as the "Stena Apache Two",  
29 is intended to be converted from the diving support  
30 vessel (DSV) "Stena Wellservicer" (not separately  
31 illustrated) by the method now to be described.  
32  
33 The method provides that the DSV will be transversely  
34 divided immediately astern of the forward bridge and  
35 accommodation section 102, and the sternwards section

1       104 separated from the forward section 102. A  
2       prefabricated hull section 106 will next be located  
3       between the forward and sternwards sections 102 and  
4       104, and the three sections then welded together to  
5       form the basis of a vessel with an extended hull. Port  
6       and starboard sponsons 108 and 110 are subsequently  
7       attached to the outside of the vessel hull from the  
8       stern to about the middle of the forward section 102 so  
9       as to increase the displacement of the resultant vessel  
10      100, and hence increase the vessel's load-carrying  
11      capacity. The sponsons 108 and 110 are also designed  
12      and attached such as to increase the longitudinal  
13      bending strength of the vessel 100.

14

15      The hull section 106 is formed with a reel-holding well  
16      112. Bearing pedestals 114 and 116 are fabricated on  
17      port and starboard sides of the well 112 to form  
18      reel-mounting bearings. A main pipe-carrying reel 118  
19      is rotatably mounted in the bearings 114 and 116. A  
20      main reel driving and braking system (not shown) is  
21      installed in the well 112.

22

23      A large auxiliary reel 120 is installed immediately  
24      forward of the main reel 118, in the redundant DSV dive  
25      system garage in the after end of the forward section  
26      102. The large auxiliary reel 120 is intended to carry  
27      cable(s) and/or auxiliary pipes.

28

29      A small auxiliary reel 122 is installed immediately aft  
30      of the main reel 118, in the redundant DSV gas storage  
31      area in the forward end of the sternwards section 104.  
32      The small auxiliary reel 122 is intended to carry  
33      cable(s) and/or hose(s).

34

35      The stern of the vessel 100 is provided with

1 substantially elevated ramp mountings 124 and 126. A  
2 ramp 128 in the form of a rectangular lattice has its  
3 rear end 130 rotatably mounted on the upper ends 132  
4 and 134 of the ramp mountings 124 and 126 (see Figs. 4  
5 and 6).

6

7 The mountings 124 and 126 are not only shaped and  
8 dimensioned to support the ramp 128 on their upper ends  
9 132 and 134 substantially above the vessel's main deck  
10 136 such as to leave walk-through headroom under the  
11 ramp 128, but also to locate their upper ends 132 and  
12 134 clear of the stern of the vessel 100 such as to  
13 enable pipe to be launched aft the ramp 128 at a  
14 near-vertical angle (see Fig. 5).

15

16 The forward end 138 of the ramp 128 is supported at a  
17 controllably variable height above the deck 136 by  
18 means of a ramp elevation controller 140 comprising a  
19 pair of rack and pinion elevators 142 and 144.

20

21 Referring to Figs. 9 and 10, each of the ramp elevators  
22 142 and 144 comprises an elongate rack 146 with a row  
23 of teeth along both edges, the racks 146 each being  
24 tiltably mounted on the deck 136 by means of a  
25 respective hinge 148. The use of deck-fixed hinges 148  
26 allows the necessary reinforcements of the deck 136 to  
27 be limited to the two relatively small areas under the  
28 hinges 148, in contrast to the widespread deck  
29 reinforcement required with prior art ramp elevators  
30 (eg, the rail-mounted ramp elevators of WO93/06401 and  
31 WO93/06402).

32

33 Each of the ramp elevators 142 and 144 further  
34 comprises a power-driven pinion assembly 150 comprising  
35 a pinion frame 152 mounting three pairs of pinions 154,

1 with one pinion of each pair engaging one of the rows  
2 of teeth on either edge of the rack 146. Each of the  
3 pinions 154 is driven by a respective hydraulic motor  
4 and reduction gear unit 156. The respective upper ends  
5 of the two pinion assemblies 150 are pivotally coupled  
6 to the forward end 138 of the ramp 128 by respective  
7 pivot couplings 158. The pinion assemblies 150 are  
8 also mutually cross-linked by a transverse frame 159.  
9

10 Conjoint operation of the hydraulic drive units 156  
11 causes the pinion assemblies 150 to crawl up/down the  
12 racks 146 hence to raise/lower the forward end 138 of  
13 the ramp 128. Control of the drive units 156 is such  
14 as to ensure (as far as possible) synchronous movement  
15 of the assemblies 150 and hence to avoid  
16 movement-induced distortion of the ramp 128 (whose  
17 structure is lighter and less rigid than the structures  
18 of the ramps described in WO93/06401 and WO93/06402).  
19 Positive synchronisation of the movements of the two  
20 pinion assemblies 150 can optionally be ensured by  
21 cross-linking at least one pinion in one assembly 150  
22 with the corresponding pinion in the opposite assembly  
23 150 by means of a transverse drive shaft (not  
24 illustrated) in addition to or as a substitute for use  
25 of the transverse frame 159.  
26

27 With the arrangement illustrated in the accompanying  
28 drawings, the ramp 128 can be rapidly adjusted to any  
29 elevation in the range from 10° above horizontal  
30 (Figs. 3 and 4) to 85° above horizontal (Figs. 5 and  
31 6). The arrangement can be modified to suit other  
32 desired ranges of ramp elevation.  
33

34 The ramp 128 does not directly carry pipe being  
35 de-spoiled from the main reel 118, but carries the pipe

1 through the intermediary of a levelwind assembly 160  
2 comprising an elongated frame 162 of rectangular  
3 cross-section (see Fig. 14). The levelwind frame 162  
4 is mounted for ramp-traversing movement by means of  
5 rollers 164 (Fig. 9) running on the ramp crossbeams  
6 forming the ramp ends 130 and 138. The ramp crossbeams  
7 130 and 138 are also fitted with transverse racks 166  
8 engaged by hydraulically-powered pinion/gearbox motor  
9 units 167 for controllably displacing the levelwind  
10 assembly 160 across the ramp 128 as necessary to ensure  
11 correct spooling/de-spooling of pipe onto/off the main  
12 reel 118 (ie, to ensure "level winding").  
13

14 The levelwind assembly 160 further includes various  
15 items of pipe-conditioning and pipe-handling equipment  
16 which are mounted on the frame 162 for controlling  
17 position, movement and shape of pipe passing through  
18 the levelwind assembly 160. Such equipment includes,  
19 by way of non-limiting example, a curved main aligner  
20 168 for imparting a controlled radius to pipe being  
21 de-spooled from the main reel 118, pipeline  
22 straightening and tensioning means comprising first,  
23 second, third and fourth caterpillar track assemblies  
24 170, 171, 172, 173, the first, second and third of said  
25 assemblies 170, 171, 172 together constituting a  
26 "three-roll" pipe straightener, and the third and  
27 fourth of said assemblies 172, 173 together  
28 constituting a pipe tensioner, at least one, and  
29 preferably a pair, of pipe clamps 174, and a roller  
30 frame 176 for pipe guidance. The items 168-176  
31 referred to above are known per se, and are described  
32 in detail in the above-mentioned WO93/06401 and  
33 WO93/06402. Alternative types of straightener,  
34 tensioner etc. may be substituted for those described  
35 herein.

1       The levelwind assembly 160 may also include similar  
2       equipment for handling auxiliary pipe(s) and/or  
3       cable(s), for example an auxiliary aligner 178 and an  
4       auxiliary straightener 180.

5

6       To facilitate procedures such as pipe inspection, pipe  
7       repairs, pipe jointing, attachment/removal of haulage  
8       couplings to/from the pipe, and other tasks that have  
9       to be performed on pipe in passage through the  
10      levelwind assembly 160, the levelwind frame 162 is  
11      fitted with a pair of work platforms 182 and 184 whose  
12      inclinations on the frame 162 are selectively  
13      adjustable to allow the platforms 182, 184 to be  
14      levelled independently of the current inclination of  
15      the ramp 128 while continuing to facilitate safe and  
16      convenient access of personnel to the pipe in that  
17      region of the levelwind assembly 160. Access is  
18      conveniently enabled by a ladder system and by a  
19      man-riding lift, with a separate system on each side of  
20      the levelwind assembly 160. The levelwind frame 162  
21      may be shrouded or boxed-in to provide full weather  
22      protection.

23

24      Occasions may arise when it is necessary or desirable  
25      to allow the end of a pipe to be let overboard in a  
26      controlled manner, or to haul the end of pipe on-board  
27      in line with the normal path of continuous pipe. To  
28      meet these requirements, the vessel 100 is rigged with  
29      an "abandonment and recovery" system (A&R system) 186  
30      which is essentially a winch system reeved partly  
31      inside the vessel 100 and partly on the levelwind  
32      assembly 160. (The version of the A&R system 186 shown  
33      in Fig. 9 differs slightly from that shown in Figs.  
34      1-6, as do certain details of the levelwind system such  
35      as the forward end of the frame 162).

1 As part of the A&R system 186, a winch 188 is located  
2 inside the hull of the vessel 100, the winch 188 being  
3 anchored on the redundant underdeck strongpoint  
4 originally employed for mounting the DSV sterndeck  
5 crane (removed). The A&R rope 190 runs from the winch  
6 188 round a pulley 192 anchored between the ramp  
7 mountings 124 and 126 up to a pulley or pulleys 194  
8 anchored on the levelwind frame 162 and hence (when  
9 deployed) down the centerline of the levelwind assembly  
10 160 along the same path as that normally taken by pipe  
11 being de-spoiled from the main reel 118. When the A&R  
12 system 186 is not required to be operative the pulley  
13 or pulleys 194 is/are moved to the side of the  
14 levelwind centerline to be clear of the pipe path (see  
15 Fig. 14). The tail of the rope 190 on the non-load  
16 side of the winch 188 is carried round a pulley 196 and  
17 onto a take-up drum 198 for tangle-free storage.

18

19 The location of the pulley 192 between the ramp  
20 mountings 124 and 126 has at least two advantages,  
21 namely the closer the pulley 192 is to being coaxial  
22 with the ramp bearings 132 and 134, the closer the A&R  
23 system 186 is to being level luffing (ie, to not  
24 pulling in or paying out as the ramp elevation  
25 changes), and secondly, obstruction of the area of the  
26 deck 136 under the ramp 128 is minimised.

27

28 Between the main reel 118 and the large auxiliary reel  
29 120 a combined pipe/cable bridge and personnel access  
30 gangway 200 is cantilevered sternwards off the rear  
31 wall of the forward vessel section 102 to pass partly  
32 over the main reel 118 at an elevation sufficient to  
33 clear pipe being de-spoiled from the reel 118 into the  
34 levelwind assembly 160, whatever the current elevation  
35 of the ramp 128. The upper side of the bridge/gangway

1       200 is fitted with lengthwise array of transverse axis  
2       rollers 202 to carry auxiliary pipe(s)/cable(s) being  
3       de-spooled from the large auxiliary reel 120 onto the  
4       ramp 128. A pedestrian-carrying gangway (not  
5       illustrated) is mounted on the bridge/gangway 200  
6       alongside the rollers 202 to allow access from the  
7       upper deck of the forward section 102 to a location  
8       close to and directly over the forward side of the hub  
9       of the main reel 118. The bridge/gangway 200 is held  
10      at the appropriate elevation by means of a strut 204,  
11      which may be of a fixed length to hold the  
12      bridge/gangway 200 at a corresponding fixed elevation;  
13      alternatively, the strut 204 may be of a controllably  
14      variable length to hold the bridge/gangway at a  
15      selectively variable elevation.  
16

17      Besides functioning as a combined bridge and gangway,  
18      the structure 200 gives a measure of protection to the  
19      forward section 102 and to the personnel therein, by  
20      shielding the forward section 102 from the  
21      uncontrollable and violent movement of the broken end  
22      of pipe should the pipe fracture between the reel 118  
23      and the aligner 168, particularly if under considerable  
24      tension (which may be as high as 200 Tonnes even when  
25      operating within design limits).  
26

27      The dynamic positioning system (DPS) of the original  
28      DSV "Stena Wellservicer" is retained in the reel  
29      pipelaying vessel "Stena Apache Two" ("100" in the  
30      accompanying drawings). The DPS retained in the  
31      converted vessel 100 comprises three variable-thrust  
32      360°-steerable stern thrusters 206, and three  
33      variable-thrust unsteerable transverse-tunnel bow  
34      thrusters 208.  
35

1 A crane 210 is mounted on the port rail of the vessel  
2 100, aft of the main reel 128 and forward of the small  
3 auxiliary reel 122. In-hull foundations of the crane  
4 210 are partly in the original DSV and partly in the  
5 conversion-added portside sponson 108.

6

7 A crane 212 is mounted on starboard rail of the vessel  
8 100, at the furthest stern of the main deck 136 (Figs.  
9 1-6 and 7-8). As with the portside crane 210, the  
10 in-hull foundations of the starboard crane 212 are  
11 partly in the original DSV and partly in the  
12 conversion-added starboard sponson 110. In order to  
13 avoid being unduly baulked by the levelwind assembly  
14 160 at the maximum elevation of the ramp 128, it is  
15 preferred to move the starboard crane further aft from  
16 the position shown in Figs. 1-6 to the position shown  
17 in the modified vessel of Figs. 7 and 8, the starboard  
18 sponson 110 and the overlying portion of the main deck  
19 136 being correspondingly extended sternwards to  
20 support the repositioned crane.

21

22 Apart from removal of the redundant dive systems, the  
23 forward vessel section 102 retains all the essential  
24 features of the forward section of the DSV; in addition  
25 to the bow thrusters 208, these retained features  
26 include the engine room (not visible), crew  
27 accommodation 214, forward bridge 216, stern bridge 218  
28 (overlooking the main reel 118 and the pipe-launching  
29 ramp 128), and helicopter landing deck 220.

30

31 Referring now to Figs. 16, 17 and 18, these show  
32 external and internal details of a reel-clamping chock  
33 300.

34

35 The chock 300 comprises a cylindrical outer casing 302

1 which is welded to the main deck 136 through the  
2 intermediary of a pair of saddle plates 304 and  
3 longitudinal reinforcing webs 306. A longitudinally  
4 slidable sleeve 308 is mounted within the outer casing  
5 302 by anti-friction bushes 310 and 312. The reel end  
6 of the sleeve 308 is fitted with a flanged plug 314  
7 having an aluminium bronze pad 316 affixed to its outer  
8 face.

9

10 Extension and retraction of the chock 300 is achieved  
11 by a hydraulic cylinder 318 and piston 320 mounted  
12 within the sleeve 308. (Hydraulic fluid connections are  
13 omitted from Figs. 16-18 for clarity). The end of the  
14 hydraulic cylinder 318 remote from the reel-contacting  
15 end of the chock 300 is anchored to the casing 302 and  
16 hence to the deck 136 by a cylinder eye 322 pinned  
17 between a pair of U-brackets 324 fixed to the end of  
18 the casing 302 by fasteners 326.

19

20 The piston 320 is coupled to the reel-contacting end of  
21 the chock by a piston eye 328 being pinned to a clevis  
22 fitting 330 secured to one end of a pushrod 332. The  
23 other end of the pushrod 332 is secured to the inner  
24 face of the plug 314.

25

26 The reel end of the sleeve 308 is externally  
27 screw-threaded with an Acme thread 334. An internally  
28 threaded ring 336 is fitted on the sleeve thread 334  
29 such that the ring 336 can be selectively positioned  
30 along the outer end of the sleeve 308 by manually  
31 turning the ring 336 around the sleeve 308. The  
32 periphery of the ring 336 is drilled with radial holes  
33 338 to enable the ring 336 to be turned by a suitable  
34 tool (not shown).

35

1 Fig. 16 shows the chock 300 fully extended such that  
2 the pad 316 forcibly engages an annular contact surface  
3 222 on the outside end face of the main reel 118.  
4 Fig. 15 also shows the ring 336 screwed up against the  
5 adjacent end of the sleeve 308 such that reel-clamping  
6 forces continue to be applied to the reel 118 even if  
7 hydraulic pressure is removed from the cylinder and  
8 piston 318 and 320, due to the mechanical locking of  
9 the chock 300 provided by suitably turning the ring 336  
10 on the sleeve thread 334.

11

12 Release of the reel-clamping chock 300 from the  
13 fully-applied position shown in Fig. 16 is achieved by  
14 unscrewing the ring 336 until it is clear of the sleeve  
15 308, then applying reversed hydraulic pressure to the  
16 cylinder 318 and piston 320 to pull the movable end of  
17 the chock 300 away from the main reel 118.

18

19 Hydraulic pressure is preferably applied in the  
20 reel-clamping direction prior to and during unscrewing  
21 of the ring 336 in order to relieve the ring 336 of  
22 loading which might otherwise hinder or prevent the  
23 ring 336 being turned.

24

25 Fig. 19 is a plan view, to a much reduced scale, of a  
26 preferred arrangement for sea fastening, ie, for  
27 clamping the main reel 118 against axial movement when  
28 not spooling or de-spooling (eg, during transit to or  
29 from a pipe-laying location, or when pipelaying is  
30 suspended due to bad weather). An array of four chocks  
31 300 (each as shown in Figs. 16-18) is secured to the  
32 main deck 136 around the lip of the reel-holding well  
33 112. One pair of the chocks 300 is disposed to engage  
34 the port side of the main reel 118, and the other pair  
35 of chocks 300 is disposed to engage the starboard side

1 of the main reel 118. Within each of these pairs of  
2 chocks 300, one chock is located on one side of the  
3 reel axis and the other chock is located on the other  
4 side of the reel axis, as shown in Fig. 19. This  
5 symmetrical array of reel-clamping chocks ensures  
6 inherent equalisation of reel-clamping forces on the  
7 reel when the chocks are fed from a common hydraulic  
8 supply, thus avoiding any tendency for the chocks to  
9 induce skewing of the main reel 118.

10  
11 Other arrangements of reel-clamping chocks are possible  
12 within the scope of the invention, for example  
13 different locations for the chocks and/or different  
14 numbers of chocks.  
15

16 Reel-clamping chocks may also be provided for the large  
17 auxiliary reel 120 and/or for the small auxiliary reel  
18 122.  
19

20 Figs. 20 to 23 show a preferred embodiment of the main  
21 reel 400 of a reel pipelaying vessel such as that  
22 described herein. Fig. 20 shows a side view of the reel  
23 400, whilst Figs 21 to 23 show sectional views on lines  
24 A-A, B-B and C-C of Fig. 20 respectively.  
25

26 The reel 400 is of a generally open construction to  
27 minimise its weight, and is formed largely from plate  
28 steel. A plurality of main spokes 402 extend radially  
29 outwards from the centre of the reel 400 and have an I-  
30 beam type configuration comprising a main planar member  
31 404 and outer and inner planar flanges 406, 408. The  
32 outer ends of the spokes 402 are connected by flange  
33 plating 410 which form the sides of the pipe-receiving  
34 well 412 of the reel 400. The flange plating 410 is  
35 strengthened by trapezoidal box-section stiffeners 414.

1     The outer and inner edges of the flange plating 410 are  
2     further strengthened by knuckles 415, 416. The floor of  
3     the well 412 is formed by hub plating 418, which is  
4     braced by internal stiffeners 420. Intermediate partial  
5     spokes 422 are located between each pair of main spokes  
6     402, extending across the width of the flange plating  
7     410.

8

9     As seen in cross section in Fig. 21, the reel has a  
10    "portal frame" configuration, without a main shaft  
11    connecting the main rotary bearings 423. This  
12    configuration improves the fatigue performance of the  
13    reel by removing the additional rigidity and associated  
14    stresses caused by the presence of a continuous shaft  
15    as in the original Apache vessel.

16

17    In this example, the reel 400 is adapted to be engaged  
18    by sea-fastening chocks, as previously described above,  
19    at portions 424 of two of the main spokes 402' on each  
20    side of the reel 400. A bracing flange 426 extends  
21    diagonally between a point adjacent the portion 424 of  
22    each of the spokes 402' and the adjacent intermediate  
23    spoke 422. The portions 424 may be formed as anti-  
24    friction pads similar to those of the chocks as  
25    previously described. This arrangement allows the  
26    chocks to be applied to the reel only when the reel is  
27    at a particular angular position. Accordingly, when the  
28    chocks are to be applied, it may be necessary firstly  
29    to rotate the reel 400 so as to align the portions 424  
30    with the chocks.

31

32    Fig. 24 illustrates an alternative arrangement, whereby  
33    the chocks may be applied to the reel at any position.  
34    In this case a continuous, annular chock bearing  
35    surface 428 extends around the reel, mounted on an

1 extension 430 of the hub plating 418. As is also  
2 illustrated schematically in Fig. 24, the contact shoe  
3 432 of the chock may be enlarged in size, in comparison  
4 with the previously described embodiment of the chock,  
5 presenting a greater contact surface area such that the  
6 bearing surface 428 of the reel can be made generally  
7 lightweight in construction.

8

9 Figs. 25(a), (b) and (c) and Fig. 26 illustrate a  
10 preferred arrangement of the pipe clamps 174 previously  
11 referred to. Figs. 3 and 9 show the use of first and  
12 second pipe clamps 174 located on the pipeline path  
13 near the aft end of the levelwind frame 162. Firstly,  
14 it is preferred that the clamps 174 have a generally  
15 cylindrical configuration as shown in Fig. 25, being  
16 formed from first and second semi-cylindrical portions  
17 450, 452 hinged together along their lengths at 454  
18 below the pipeline path. Secondly, it is preferred that  
19 the clamps be mounted so as to be retractable out of  
20 the pipeline path when not in use (as shown in Fig.  
21 25(a)). Thirdly, it is preferred that one of the clamps  
22 (most preferably the uppermost clamp closest to the  
23 tensioner 172,173) is removable. The maximum clamping  
24 force provided by the two clamps is only likely to be  
25 required in a minority of cases. Accordingly, it  
26 desirable that the second clamp be removable to provide  
27 a greater work space when it is not required for a  
28 particular operation. If the second clamp is removable,  
29 then only a single retractable mounting need be  
30 provided for the first clamp. The mounting will be  
31 constructed to be capable of taking the total design  
32 load of both clamps, and the second clamp may simply be  
33 attached to the pipe immediately above the first clamp.  
34 This arrangement is schematically illustrated in Fig.  
35 26, where the first clamp is designated 174a, the

1 second clamp is designated 174b, the mounting,  
2 partially hidden beneath the first clamp, is designated  
3 440, and the pipeline 442 is being unspooled in the  
4 direction of the arrow A, the load on the clamp  
5 mounting 440 being in the direction of the arrows B.

6

7 The clamps may be of the type having a rubber lining  
8 and hydraulic packers as is known in the art. Fig.  
9 25(c) shows the clamp extended and closed to engage the  
10 pipeline, and Fig. 25(b) shows the clamp in an  
11 intermediate position between the retracted/open  
12 position of Fig. 25(a) and the extended/closed position  
13 of Fig. 25(c).

14

15 While preferred embodiments of the invention have been  
16 described above, the invention is not restricted to  
17 these forms, and modifications and variations of these  
18 embodiments can be adopted without departing from the  
19 scope of the invention.

20

1       Claims

2

3       1. A pipe-launching ramp, said ramp comprising a  
4       planar frame having bearing means at or towards one end  
5       thereof for rotatably mounting the ramp on ramp-  
6       mounting bearings of a pipelaying vessel, and coupling  
7       means located at or towards the other end of the frame  
8       for coupling of the ramp to a ramp elevation control  
9       means for controllably varying the elevation of the  
10      ramp.

11

12      2. A pipe launching ramp as claimed in Claim 1,  
13      wherein said ramp elevation control means comprises  
14      variable-length ramp support means adapted to be  
15      anchored at or adjacent one end thereof upon fixed  
16      structure of the vessel and at or adjacent the other  
17      end of a variable length portion of the support to the  
18      ramp at a location thereon not adjacent said rotational  
19      mounting of said ramp.

20

21      3. A pipe launching ramp as claimed in Claim 2,  
22      wherein said variable-length ramp support means  
23      comprises a pair of rack and pinion elevators located  
24      one on each side of said ramp and conjointly operable  
25      to vary the elevation of said ramp with respect to said  
26      vessel.

27

28      4. A pipe launching ramp as claimed in any preceding  
29      Claim, wherein said pipe-launching ramp comprises a  
30      pipe radius control means for imparting a substantially  
31      uniform radius of curvature to a length of pipe de-  
32      spooled from said reel in pipelaying operation of said  
33      vessel.

34

35      5. A pipe launching ramp as claimed in any preceding

1    Claim, wherein said pipe-launching ramp further  
2    includes pipe gripping means for gripping a pipe being  
3    de-spoiled over said ramp to apply straightening and/or  
4    tensioning forces to said pipe.

5

6    6. A pipe launching ramp as claimed in any preceding  
7    Claim, wherein said pipe-launching ramp comprises  
8    level-wind means for accommodating variations in the  
9    lateral positioning of a length of pipe spooled onto  
10   said reel as a plurality of side-by-side turns, during  
11   spooling and de-spooling of said length of pipe.

12

13   7. A pipe launching ramp as claimed in Claim 6 when  
14   dependent upon Claim 4, wherein said level-wind means  
15   and said pipe radius control means are mounted and  
16   controlled for conjoint lateral movement.

17

18   8. A pipe launching ramp as claimed in Claim 7,  
19   wherein said pipe radius control means is mounted upon  
20   said level-wind means for carriage thereby.

21

22   9. A pipe launching ramp as claimed in any one of  
23   Claims 6 to 8, wherein said ramp includes at least two  
24   levelwind-mounting crossbeams; said levelwind means  
25   comprising a rectangular lattice mounted for lateral  
26   movement on said crossbeams, lateral movement control  
27   means for laterally moving said lattice on said  
28   crossbeams, radius control means carried on said  
29   lattice for imparting a uniform curvature to a pipe  
30   being de-spoiled over said ramp, and pipe gripping  
31   means carried by said lattice for gripping a pipe being  
32   de-spoiled over said ramp to apply straightening and/or  
33   tensioning forces to said pipe.

34

35   10. A pipe-launching ramp as claimed in Claim 9,

1 wherein the levelwind lattice is boxed in or surrounded  
2 to provide full weather protection.  
3

4 11. A pipe-launching ramp as claimed in Claim 9 or  
5 Claim 10, wherein the levelwind lattice is equipped  
6 with a dual bulkhead/platform system to provide a  
7 working location which allows personnel to work on the  
8 lattice whether the ramp is near horizontal or near  
9 vertical.

10  
11 12. A pipelaying vessel including a pipe-launching  
12 ramp as claimed in any one of Claims 1 to 11.  
13

14 13. A pipe-launching ramp substantially as  
15 hereinbefore described with reference to the  
16 accompanying drawings.  
17

18 14. A pipelaying vessel including a pipe-launching  
19 ramp substantially as hereinbefore described with  
20 reference to the accompanying drawings.  
21

Patents Act 1977

Examiner's report to the Comptroller under Section 17  
(the Search report)Application number  
GB 9503282.7**Relevant Technical Fields**

- (i) UK Cl (Ed.N) F2P (PL2, PL9)  
 (ii) Int Cl (Ed.6) F16L 1/225, 1/235, 1/20

Search Examiner  
R F PHAROAHDate of completion of Search  
18 MAY 1995**Databases (see below)**

(i) UK Patent Office collections of GB, EP, WO and US patent specifications.

Documents considered relevant  
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1-14

(ii) ONLINE: WPI

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Category	Identity of document and relevant passages		Relevant to claim(s)
X,E	GB 2283297 A	(STENA) published 3 May 1995. See page 23, lines 23-31, page 10, lines 13-27	1, 4, 5, 6, 7, 12
X	GB 2224803 A	(ADVANCED MECHANICS) see page 11, line 22 - page 12, line 4	1, 2, 12
X	GB 2214259 A	(HEEREMA) see page 3, lines 27-32	1, 2, 12
X	GB 1507959 A	(SANTA FE) page 2, lines 32-47	1, 2, 4-6, 12
X	US 3860122 A	(CERNOSEK) see column 4, lines 31-51	1, 2, 5, 12

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